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JOURNAL

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Bombay Natural History Society

Vol. 83, No. 3

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2. The MS. should be typed (double spacing) on one side of a sheet only, and the sheets properly numbered.

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THE BIRDS OF KANHA TIGER RESERVE, MADHYA PRADESH, INDIA[1]

Paul N. Newton[2], Stanley Breeden[3] and
Guy J. Norman[4]

(*With two text-figures*)

Introduction

Kanha Tiger Reserve is a 1945 sq. km. tract of hill forest, near the geographic centre of India, famous for its abundance of large mammals. Although field research has been conducted within the Reserve (Panwar n.d., Kotwal n.d., Schaller 1967, Kurt 1973, Martin 1977, Newton 1984) birds have been neglected, reflecting the general paucity of information on the central Indian avifauna (Hewetson 1955). The purpose of this paper is to present the authors' records of birds in Kanha, collated with previous published observations.

Most of the previous ornithological fieldwork in central India has been conducted in the western, often more arid, areas of Berar, Gwalior, Bhopal and Betul (Osmaston 1927, Ali 1939, Hewetson 1939, Wright 1942). D'Abreu (1935) published a list of 409 species for the, as then, Central Provinces, but included 42 species of uncertain occurrence. Subsequently, Hewetson (1955) recorded 308 species, seen during 29 years forest service in the Central Provinces and, its administrative descendant, Madhya Pradesh. Although Hewetson (1955), Anderson (1979) and Ranjitsinh (1983) recorded some specific bird species from Kanha, Panwar (n.d.) produced the first list of birds seen in the tract, based on some 12 years residency. Guntert & Homberger (1973) added

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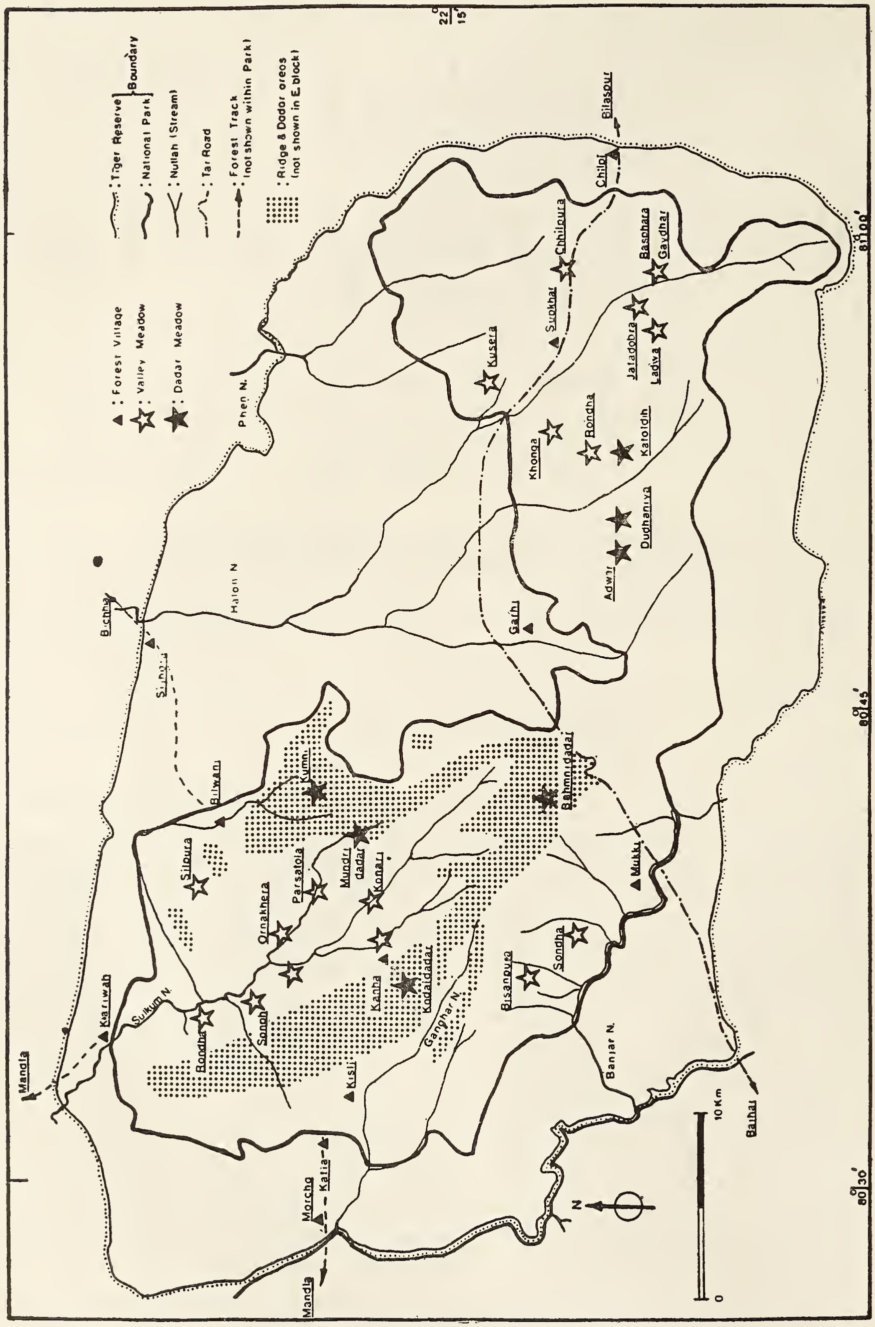
Tiger Reserve
National Park
Boundary
Nullah (Stream)
Tar Road
Forest Track (not shown within Park)
Ridge & Dadar areas (not shown in E. block)
Forest Village
Valley Meadow
Dadar Meadow
Phen N.
Halon N.
Sulkum N.
Banjar N.
Banjar N.
Mandla
Kariwah
Bichhia
Bilwani
Silpura
Bondha
Sonph
Ornakhera
Parsatola
Mundri dadar
Konari
Kanha
Kodaidadar
Kisli
Bahmnidadar
Mukki
Bisanpura
Sondha
Gaghar N.
Gadhi
Adwar
Dudhaniya
Khonga
Bondha
Katoldih
Kusera
Sukhar
Chhilpura
Chilpi
Bilaspur
Basphara
Gaydhar
Jatadobra
Ladwa
Morcha
Katia
Baihar
N
0
10 Km
22°15'
81°00'
80°45'
80°30'

Fig. 1. Kanha Tiger Reserve. Madhya Pradesh.

to this list during a month long intensive ornithological survey, which included mist netting.

KANHA TIGER RESERVE

The reserve, 50 km SE of Mandla town, is situated in the Mandla and Balaghat districts of Madhya Pradesh (M.P.) in the Maikal Hills of the Central Indian Highlands (22° 17′ N, 80° 38′ E). Kanha Tiger Reserve encloses the 940 sq. km. forests of Kanha National Park and a surrounding 1005 sq. km. buffer zone of forest, villages and cultivation (Figs. 1 & 2). The only permanent inhabitants in the National Park are the Forest Department staff. Pertinent aspects of the natural history of the reserve are summarized below. For further details see Panwar (n.d.), Forsyth (1872), Rudman (1912), Brander (1923), Schaller (1967) and Newton (1984).

a) *Topography and Geology.*

The landscape comprises flat-topped hills and ridges enclosing valleys and amphitheatres, rising from 450 m to 950 m above m.s.l. The ridges tend to run E-W, producing spurs which project northwards. The Reserve is isolated from other forest areas in the Maikal Hills by cultivation in the surrounding lower lying tracts. The drainage pattern reflects the division of the Park into a western block, drained by the Banjar River and an eastern block drained by the Halon River, both tributaries of the River Narmada. The two hill blocks are separated, apart from the narrow Bhaisanghat neck, by farmland and villages. This report deals only with the ornithology of the west block (Kisli, Kanha and Mukki Forest Ranges) — an 8 km wide amphitheatre drained to the north by the Sulkum nullah (see Figs. 1 & 2). Geologically, the region is composed of gneiss, crystalline schists and Deccan trap.

b) *Habitats.*

Four main vegetation types can be distinguished within the Park, moist deciduous forest, dry deciduous forest, valley meadow and dadar meadow (Kotwal n.d., Schaller 1967, Newton 1984). By the Champion & Seth (1968) classification, forest types 3C/C2ei, 3C/C2eii, 3B/C2 and 5A/C3 are represented. The moist deciduous forest, comprising 27% of the Park area and found below about 600 m, is dominated by sal (*Shorea robusta*). In the valleys, sal is associated with an undergrowth of *Flemingia* species whilst on the lower slopes it is found with a tangle of bamboo (*Dendrocalamus strictus*). Whilst most species are deciduous, sal, forming 30-80% of trees, is semi-evergreen. The forest is fragmented into meadows (1 ha-6 sq. km.), dotted with trees, forming 21% of the Park area. These are the relics of Baiga 'bewar' slash-and-burn cultivation, halted about 1868. The largest meadow has Kanha Forest Village at its western edge and is referred to as the Kanha meadow.

Above some 600 m, sal-with-bamboo gives way to dry or mixed deciduous forest (51% of park area) which also forms islands on rocky outcrops ('chattans') in sal forest. Although lower in stature than sal forest it has a much greater species diversity. Owing to laterite and bauxite deposits, inimical to tree growth, the plateaux are frequently vegetated with meadow. In the buffer zone patches of forest, degraded by human use, are scattered amongst settlements, pasture and paddyfields.

The major nullahs (streams) and open water habitats (tanks, anicuts, bunds) are shown on Figs 1 & 2. The major still water bodies are Shrawantalao, Kanha anicut (both about 1 ha surface area), Sonph, Rondha, Sondha, Kisli tanks (about 1/3 ha each) and Menhar bund (1/6 ha) in the valleys and Deotalao (1/3 ha) in the hills. All appear, at least in their present

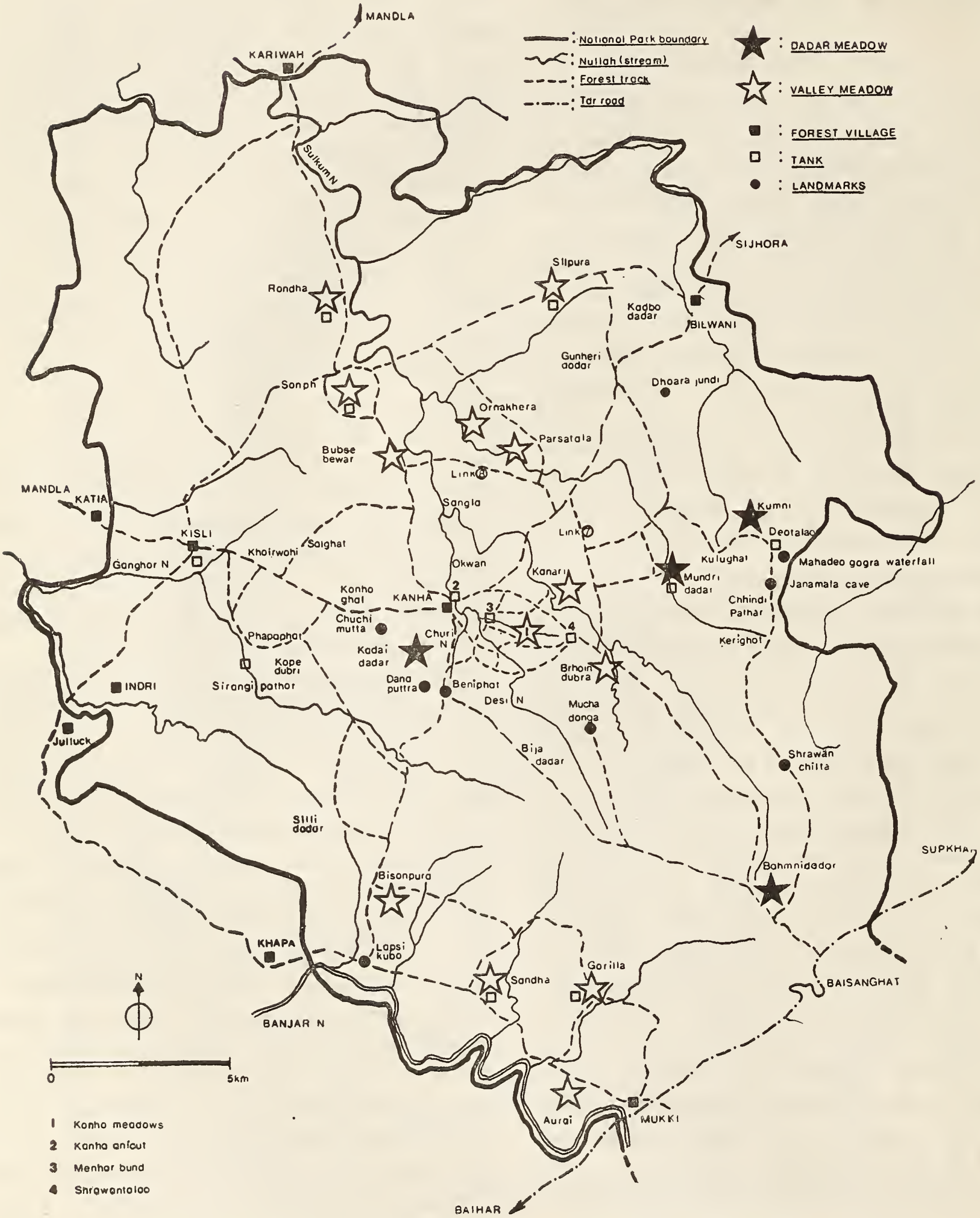
National Park boundary
Nullah (stream)
Forest track
Tar road
DADAR MEADOW
VALLEY MEADOW
FOREST VILLAGE
TANK
LANDMARKS
MANDLA
KARIWAH
Sulkum N
SIJHORA
Silpura
Rondha
Kadbo dadar
BILWANI
Gunheri dadar
Dhoara jundi
Sonph
Ornakhera
Parsatola
Bubse bewar
Link 8
MANDLA
KATIA
Sangla
Link 7
Kumni
Deotalao
KISLI
Saighat
Khoirwahi
Kulughai
Mahadeo gogra waterfall
Ganghar N
Okwan
Kanari
Mundri dadar
Janamala cave
Konho ghat
KANHA
Chhindi Pathar
Chuchi mutta
Phapaphat
Churi N
Kerighat
Kadai dadar
Kope dubri
Brhoin dubra
INDRI
Sirangi pathar
Dana puttra
Beniphat
Desi N
Mucha donga
Julluck
Bija dadar
Shrawan chilta
Silli dadar
SUPKHA
Bisonpura
Bahmnidadar
KHAPA
Lapsi kubo
BAISANGHAT
Sandha
Gorilla
N
BANJAR N
0
5km
Aurai
MUKKI
BAIHAR
1 Konho meadows
2 Kanha anicut
3 Menhar bund
4 Shrawantalao

Fig. 2. Kanha National Park, Kisli, Kanha and Mukki Forest Ranges.

form, to be manmade. There are considerable seasonal variations in water level and nullahs cease flowing during the hot weather.

The diverse and abundant mammalian fauna (Schaller 1967) has been successfully conserved by Project Tiger and the Forest Department, and the decline of many species reversed. The region has been inhabited by the Baiga forest tribe for a considerable, but unknown, length of time living by slash-and-burn cultivation and as hunter-gatherers. Much of the valley sal is probably secondary forest, owing to logging at the turn of the century. The area, previously known as the Banjar Valley Reserve Forest, was declared a Sanctuary in 1933 and has had variable degrees of protection since then.

c) *Climate.*

Three seasons can be identified; cold weather, hot weather and monsoon. The cold weather (November-March) is cool and dry (< 5-7 cm of rain) with minimum and maximum temperatures of 5° and 25°C respectively. Leaf fall commences in January in most tree species.

During the hot weather (April-June) minimum and maximum temperatures are about 20°C and 42°C respectively. It rarely rains and deciduous trees renew their leaves and then flower. Sal trees flush soon after their leaves fall and then flower *en masse*.

The timing of the monsoon is variable, usually heralded by afternoon showers in late May, culminating in continuous rain in late June. This transforms the dessicated habitat into a cool (20-30°C), humid and very wet environment until October. Rainfall at Kanha village was 1495 mm in 1980 and 1766 mm in 1981 (Kotwal pers. comm.).

Systematic List

Those bird species known to the authors to occur in Kanha Tiger Reserve are listed below with notes on their natural history. The nomenclature and taxonomic arrangement follows Ripley (1982) for birds, Deoras (1978) for snakes and Brandis (1874) for trees. As subspecific identifications were not made (no birds were caught) the Handbook numbers of Ali & Ripley (1968-1974) have not been used. Authorship for specific records are given by initials (PN, SB, GJN). All localities mentioned are given on Figs. 1 & 2 and all records refer to the western block. The authors were present in Kanha for the following periods:

PN: Jan.-July 1980; Jan. 1981-July 1982; April-May 1983.
SB: April 1982-July 1983.
GJN: Dec. 1980-March 1981.

Dates are given in the order day/month/year. All measurements are given in SI units. The term '1st call/return' records the date on which the species was first heard/seen in any year, after its absence during the monsoon. The seasonal occurrence of bird species was classified into three categories, defined below and indicated in the list, together with breeding records. These categories are necessarily arbitrary but reflect what is known of the pattern of Indian migration (Ali & Ripley 1968-74). The abbreviations and symbols used in the list for previous records, habitats and classes of migratory status are given below:

Previous records

*: previously recorded by Guntert & Homberger (1973).
†: „ „ „ Panwar (n.d.).

Habitats

(M) : valley meadow
(Salf) : sal forest with *Flemingia*
(Salb) : sal forest with bamboo

(Mx) : mixed forest
(D) : dadar meadow
(N) : nullah or stream
(T) : open water or tank
(C) : buffer zone farmland

Migratory status

[R] : Resident, observed in every month of the year.
[W]: Winter visitor, observed only between October and April.
[w] : Winter and Summer visitor, observed only between October and July.
[B] : Breeding, observed at nest, as fledglings or carrying nesting material.

SYSTEMATIC LIST

PODICIPEDIDAE

Podiceps ruficollis Little grebe
(T) [w] Nov.-July. Up to 5 on Kanha anicut, 6 on Sondha tank, also Sonph tank & Shrawantalao.

PHALACROCORACIDAE

Phalacrocorax carbo Cormorant
(T) 15/2/82, 22/2/82, 24/2/82. 1 on Kanha anicut (PN).

P. fuscicollis Indian shag*
(T) 28/4/82, at Sondha tank (SB).

P. niger Little cormorant*
Recorded by Guntert & Homberger (1973) at Desi nullah, 7/9/72.

ARDEIDAE

Ardea cinerea Grey heron
(T) 30/4/83-22/6/83, 1 at Shrawantalao & Menhar bund. 15/6/83, 1 at Sondha tank (SB).

A. purpurea Purple heron
(T,N) [w] Feb.-June. 1-2 at Kanha anicut, occasionally also at Shrawantalao.

Ardeola grayii Pond heron*,†
(T,N,M,D) In all months except Aug. In monsoon numbers considerably reduced with some birds foraging on meadows. Near water throughout valley and occasionally at nullah pools and ponds in hills at Kerighat, Deotalao.

Bubulcus ibis Cattle egret*,†
(T,M,Salf) [w] Dec.-June. Common around Kanha anicut. Transition to breeding plumage in May. For description of 'leapfrogging' see Newton (1986).

Egretta intermedia Smaller egret†
(T,N) [w] Jan.-June. 1-2 at Kanha anicut, occasionally at Shrawantalao, Menhar bund. 20/6/82, a bird in breeding plumage, Menhar bund (SB).

E. garzetta Little egret†
(T,N) 21/5/83, 25/5/83, 1 at Kanha anicut (PN). 21/4/82, 1 Menhar bund. 17/1/83, 1 Sondha tank (SB).

CICONIIDAE

Ciconia episcopus Whitenecked stork†
(T,N,M) [w] Dec.-June. At Kanha anicut, Menhar bund, Shrawantalao. In late hot weather about 6 birds at streams traversing central Kanha meadow.

C. nigra Black stork
(T) 22/11/82, Kanha anicut. 22/1/83 Kanha meadow, 2 flying (SB). A rare species in the Deccan, at the southern limit of its range (Ali & Ripley 1968-74).

Leptoptilos javanicus Lesser adjutant*,†
(N,M,T) [w] March-June. Kanha anicut, Menhar bund, Shrawantalao, Sondha tank. At forest pools in Sulkum nullah during hot weather. Hewetson (1955) recorded this species in Kanha in 1955, his only record for the state.

THRESKIORNITHIDAE

Threskiornis aethiopica White ibis
7/7/83, 5 flying over Kanha meadow (SB).

Pseudibis papillosa Black ibis†
(T,N,Salf) [R] In all months, roosting in sal (*Shorea robusta*) at Kanha Forest Village, foraging around Kanha anicut and surrounding meadows and nullahs.

ANATIDAE

Dendrocygna javanica Lesser whistling teal*,†
(T) [w] Nov.-July. Shrawantalao, Sondha tank and Kanha anicut. Maximum of about 350 birds in January at Kanha.

Anas acuta Pintail†
(T) [W] Nov.-March. Shrawantalao, Kanha anicut, Sondha tank. Maximum of 50 birds at Kanha in January.

A. crecca Common teal*
(T) [W] Nov.-March at Shrawantalao, Menhar bund, Mundri dadar bund, Sondha & Sonph tanks. Maximum of 50-60 birds at Shrawantalao.

A. poecilorhyncha Spotbill duck
Recorded by Anderson (1979) on Shrawantalao.

A. penelope Wigeon
(T) 15/11/81, Sondha tank (R. Wolton & PN).

A. querquedula Garganey
(T) 17/1/83, 8 Sondha tank (SB).

A. clypeata Shoveller
(T) 10/11/82, a female at Shrawantalao (SB).

Nettapus coromandelianus Cotton teal*
(T) [w] Feb.-July. 5-6 at Kanha anicut. Also at Shrawantalao and Sondha tank.

ACCIPITRIDAE

Elanus caeruleus Blackwinged kite*
(M, Salf, D, Mx) [w, B] Oct.-June. Kanha, Rondha and Sonph meadows, Bahmnidadar, Silpura, Shrawanchitta cliffs, Muchadonga. Breeding Kanha meadow Feb/81 and Oct/83, latter nest 8 m up *Butea monosperma,* 3/10/82 2 eggs, 11/10/82 4 eggs, 5/11/82 2 chicks, 8/11/82 4 chicks, 30/11/82 one chick dead (SB).

Pernis ptilorhyncus Honey buzzard
(Salf, Salb, M) [R] All months. 10/7/82, caught, but dropped, a *Rana tigerina* frog (SB).

Milvus migrans Black kite†
(M, C) Common in buffer zone at Morcha village. Only once recorded within Park, 24/6/82, over Kanha meadow (SB).

Accipiter badius Shikra†
(M, Salf) [w] Oct.-July. Common on Kanha meadows; in May & June frequent bathers at nullah waterholes (SB). 17/4/81, caught and killed common myna (*A. tristis*) (PN). 2/6/82, a shikra tried unsuccessfully to remove young of common myna (*A. tristis*) from tree hole nest (SB). Attempted predation of spotted dove (*S. chinensis*) and black drongo (*D. adsimilis*) also observed (GJN). This species possibly confused with Asiatic sparrowhawk (*Accipiter nisus*), a winter visitor to central India (Ali & Ripley 1968-74).

Butastur teesa White-eyed buzzard-eagle
(M, Salf, Mx) [w] Oct.-July. Kanha meadows, Bahmnidadar, Sonph, Silpura.

Spizaetus cirrhatus Crested hawk-eagle*†
(M, Salf, Mx) Jan.-June, August, November. Kanha, Kisli, Kodaidadar, Rondha. 31/1/80, feeding on Indian hare (*Lepus nigricollis*) in sal forest (PN).

Sarcogyps calvus King vulture*
(M, Salf) Feb.-Aug. Only observed on the Kanha meadows, always singly. Also 1 at tiger kill 14/2/1979 at Kisli (C. G. Bowden).

Gyps indicus Indian longbilled vulture*†
23/11/81, 1 bird flying over Kanha meadow (PN), Guntert & Homberger (1973) noted this species as considerably rarer than *G. bengalensis.*

G. bengalensis Whitebacked vulture*

(M, Salf) [R] All months, common on Kanha & Sonph meadows, scavenging tiger (*P. tigris*) and dhole (*C. alpinus*) kills.

Neophron percnopterus Scavenger vulture†

19/4/80, 31/3/82, singletons flying over meadow and sal forest, Kanha meadow. Common in buffer zone.

Circus macrourus Pale harrier

(M, D) 20/1/81, 1 Bahmnidadar. 24/12/82-8/1/83, a male on Kanha meadow. 10/1/83, eating a lizard (SB). 17/1/82, 2 males Sondha meadow.

C. melanoleucos Pied harrier

(M, D) [W] Dec.-April. Bahmnidadar. 25/4/80, 23/12/82 Kanha meadow.

C. aeruginosus Marsh harrier

(M, D) [W] Feb.-March, June & Nov. Bahmnidadar, Sonph & Kanha meadows. The June record may represent the northerly passage of birds loitering during the hot weather in Sri Lanka (Ali & Ripley 1968-74).

Spilornis cheela Crested serpent eagle*†

(Salf, Mx) [R] All months. Calling Jan.-Feb. 23/3/81, chasing peacock (*Pavo cristatus*). 27/6/82, carrying 1 m long *Boiga* snake in talons. 11/7/82, caught and ate striped keelback snake (*Amphiesma stolata*). 5/1/82, eating checkered keelback snake (*Xenochrophis piscator*) (SB).

Falconidae

Falco biarmicus Lanner falcon†

(M) 14/5/80, 7/1/83, 13/1/83, Kanha meadow. 6/3/81, Sonph meadow, stooped at a dove.

F. peregrinus Peregrine falcon*

Recorded by Guntert & Homberger (1973) at Deotalao in mixed forest, 15/9/72.

F. tinnunculus Kestrel

(M, Salf) [W] Nov.-Dec., Feb.-March. Kanha meadow.

Phasianidae

Francolinus francolinus Black partridge†

Recorded by Panwar (n.d.).

F. pictus Painted partridge*†

(M) April-Aug. Common on Kanha meadow, also Sonph, Silpura. Calling April to August and 31/12/82. 1st call 30/4/81, stopped with break of monsoon, resumed 25/7/81. 1st call 20/4/82.

F. pondicerianus Grey partridge

(M, Mx) [w] Oct., Nov., Jan., July. Sonph, Mukki, Beniphat, Morcha.

Coturnix coturnix Common quail†

(M, Mx) [w] Dec., March, June. Kanha Sonph, Mukki.

C. coromandelica Rain quail

(M) 14/6/82, Kanha meadow, after rain (SB).

Perdicula asiatica Jungle bush quail*†

(M, D) [w] Jan.-June. Kanha meadow, Bahmnidadar, Bijadadar.

Galloperdix spadicea Red spurfowl

(Mx) [w, B] Dec.-April, June-July. Kodaidadar, Silpura, Bahmnidadar, Bisanpura, Kisli particularly common in bamboo thickets. 10/6/82, pair with two half-grown chicks at Kisli (SB).

Gallus gallus Red junglefowl*†

(Salf, Salb, Mx) Nov.-Aug. Common throughout forest areas.

Pavo cristatus Peafowl*†

(M, Salf, Salb, Mx) [R, B] All months, common throughout Park, especially around meadows. 13/7/81, peahen + 3 chicks, 1 chick later scavenged by *Spilornis cheela* and jackal (*C. aureus*). 8/5/83, nest 4 eggs. 6/6/83, nest 4 chicks, 11/6/83, nest 4 chicks (SB).

Gruidae

Grus antigone Sarus crane

A pair in marsh at Khapa, in buffer zone

2/4/82, noted by Mr. R. H. Wright. Also occurs at Julluk (Mungal, pers. comm.). Not noted within Park.

RALLIDAE

Rallus striatus Bluebreasted banded rail
(N,T) 6/7/82, 24/6/83, Desi N. 10/7/82, Menhar bund. 3/7/83, at pools on Kanha meadow after heavy rain (SB). Data suggest that birds may move into the Park for a few weeks after the break of the monsoon.

Porzana pusilla Baillon's crake
(T) 11/3/81, 1 in swamp at edge of Kanha anicut (GJN).

Amaurornis akool Brown crake
(N) May, June, Jan. Churi N, Desi N on Kanha meadow.

A. phoenicurus Whitebreasted waterhen*
(N, T) 3/6/81, 3/6/82, Kanha anicut, Parsatola tank. Skulking in pond edge vegetation. Guntert & Homberger (1973) also recorded this species at Deotalao.

Gallinula chloropus Moorhen
(T) [w] Feb., March, May. Kanha anicut.

OTIDIDAE

Sypheotides indica Lesser florican
Recorded by Ranjitsinh (1983) in Kanha (Kanheri maiden) in June 1969 and May 1971.

JACANIDAE

Hydrophasianus chirurgus Pheasant-tailed jacana
(T) 17/1/83, three on Sondha tank (SB).

Metopidius indicus Bronzewinged jacana
(T) [w] Jan.-June. Kanha anicut up to 10 birds, also Sondha tank, Shrawantalao. 29/3/81, 2 mating on nullah bank (GJN).

ROSTRATULIDAE

Rostratula benghalensis Painted snipe
(T, N) [w] March, May, June. A pair at Menhar bund, also Rondha tank.

RECURVIROSTRIDAE

Himantopus himantopus Blackwinged stilt
(T) Oct.-Dec. At tank, Morcha village. Not noted within Park.

BURHINIDAE

Burhinus oedicnemus Stone curlew
(M, Mx, D) [w, B] Feb.-July. Kanha meadow, Kodaidadar, Bahmnidadar, Brhoindubra. Most frequently calling in May. 1st call 13/3/82. 27/4/82, three stone curlew eggs in small fire, with *Cordia* 'gursa' Baiga fire-making sticks, on nullah bank near Morcha village. 25/5/82 a nest with 2 eggs in meadow copse. A second nest with 2 eggs, no adults, with spring snare set around nest. Snare, made of *Bauhinia vahlii* and *Cordia latifolia,* forming fibrous noose attached to a 3′ long split bamboo spring, stuck vertically in ground (PN).

CHARADRIIDAE

Vanellus indicus Redwattled lapwing†
(M, D, N, T) [w, B] Oct.-July. Kanha, Kisli, Sonph, Sondha meadows, Kodaidadar, Deotalao. 2/6/82, nest 2 eggs Sulkum N. 30/5/83, nest, downy chicks, Kanha meadow, 10/6/83, nest 3 eggs Kanha meadow, drowned in heavy rain (SB).

V. malabaricus Yellow-wattled lapwing†
(M) [w] Jan.-July. Kanha, Kisli and Rondha meadows. Much rarer than *V. indicus.*

Tringa erythropus Spotted redshank
(T) Nov. 82, at tank, Morcha village (SB). Not observed within Park.

T. nebularia Greenshank
(N) [W] Dec., March. Churi & Desi N. (PN).

T. ochropus Green sandpiper*
(N) [W] Oct.-April. Sulkum, Desi N., Mundri dadar, Shrawantalao, Kisli.

T. glareola Wood sandpiper
(T, N) [W] Jan., March, April. Sulkum, Desi N., Sonph & Sondha tanks, Deotalao. Most records from March.

Gallinago gallinago Fantail snipe
(M, T) [W] Dec., March Swampy ground on Kanha, Rondha & Sonph meadows.

COLUMBIDAE

Treron phoenicoptera Green pigeon*†
(M, Salf, Mx) June-August, Nov.-March. Kanha, Kisli meadows. Flocks of 50-100 common on meadows, feeding at saltlicks and *Ficus* trees.

Columba livia Blue rock pigeon*†
(M, Salf) Dec., Jan., March, June, Aug., Oct. Kanha, Kisli, Sonph, Mukki.

Streptopelia orientalis Rufous turtle dove
(M, Salf, Mx, D) Dec.-April, June-Oct. Kanha, Kisli, Sonph, Kodaidadar. Commonly feeding at saltlicks.

S. decaocto Indian ring dove*†
(M, Salf, D) [B] Oct.-March, June-Aug., Oct. Sonph, Kisli, Kodaidadar. Calling Jan.-March. 8/3/82, aerial display. 19/4/82, nest with two eggs, Morcha village (SB).

S. tranquebarica Red turtle dove*
(M, Salf, D) Jan., March-June, Aug., Oct. Kanha, Kisli, Sonph, Deotalao.

S. chinensis Spotted dove*†
(M, Salf, D) [R, B] All months. Kanha, Kisli, Sonph, Kodaidadar, Deotalao. 27/4/82, pair mating in sal forest. 4/5/82, nest with 2 eggs Morcha village (SB).

Chalcophaps indica Emerald dove
(M, Salf, Salb) June, July. Kanha, Kisli, Sondha, Parsatola meadows. Recorded by Hewetson (1955) in May 1955 in Kanha.

PSITTACIDAE

Psittacula eupatria Large Indian parakeet*
(M, Salf) [R] All months. 2/82, feeding *Ventilago calyculata* kernels.

P. krameri Roseringed parakeet*†
(M, Salf) [R] All months. Throughout Sulkum valley, less common in hills, Kanha, Kisli, Sonph, Kodaidadar.

P. cyanocephala Blossomheaded parakeet†
(M, Salf, Salb, Mx) [W] Oct.-March. Kanha, Sonph meadow, Kodaidadar. Feeding on *Ficus glomerata* figs in October, *Ficus religiosa* in January.

CUCULIDAE

Clamator jacobinus Pied crested cuckoo†
(M) Only observed in June 1981, 82 during pre-monsoon shower spells, catching grasshoppers & termites on Kanha meadow. Not observed in June 1983. Probably a passage migrant en route to breeding grounds (Ali & Ripley 1968-74).

Cuculus varius Common hawk-cuckoo*†
(M, Salf, Mx, D) [w] Dec.-June. Common in Sulkum valley and surrounding hills. Calling Jan.-March 1982. 1st call 10/1/82.

C. micropterus Indian cuckoo
(M, Salf, Salb, Mx) [w] Feb.-July. Sulkum valley and surrounding hills. Calling April-July 1981. 1st call 14/4/81 & 26/2/82.

C. canorus Cuckoo
(M, Salf, Mx) [w] April-June. Calling April-June in Sulkum valley and surrounding hills. 1st call 29/4/81.

Cacomantis sonneratii Indian banded bay cuckoo
(M) 10/5/82, 1 at Churi nullah. 4/5/83, 1 at Kanha meadow (SB).

Eudynamys scolopacea Koel†
(Salf) [w] Oct.-June, Kanha, Kisli. Calling March-June. In October feeding *Ficus tomentosa* fruits.

Taccocua leschenaultii Sirkeer cuckoo*
(M, Salf, Mx) [w] Oct., Nov., Jan.-May, commonly observed from Kanha-Sonph track, also Silpura, Chuchi mutta, Kisli.

Centropus sinensis Coucal*†
(Salb, Mx) [R, B] All months, in bamboo forest of Sulkum valley, particularly in upper reaches of Churi nullah. 25/6/82, nest building in bamboo, Kanha meadow. Calling April-Aug., Oct., Nov.

STRIGIDAE

Tyto alba Barn owl†
(M, Salf) 20/3/80, Shrawantalao. 30/3/81, Desi nullah (PN). Possibly confused with the Grass owl (*T. capensis*).

Otus bakkamoena Collared scops owl*
(Salf) Feb.-March. Identified by call in sal forest around Kanha meadow.

Bubo bubo Eagle-owl†
Recorded by Panwar (n.d.).

B. zeylonensis Brown fish owl†
(Salf, Mx) Oct.-Nov., Jan., March-May, heard calling around Kanha and Kisli meadows, also Mahadeo gogra.

Glaucidium radiatum Jungle owlet*
(Salf, Salb, Mx) [w, B] Jan.-July, Oct. Kanha meadow, Kisli, Sonph, Kodaidadar, Morcha. Calling Feb.-June. 21/4/82, nest 2 eggs in old woodpecker hole, Morcha (SB).

Ninox scutulata Brown hawk-owl
(Salf) [B] 26/4/82, pair at nest in shallow hollow 4 m up sal (*Shorea*) tree, Churi nullah (SB).

Asio flammeus Shorteared owl
(Mx) 2/3/81, 14/3/81, 28/3/81, Bahmnidadar (GJN).

CAPRIMULGIDAE

Caprimulgus indicus Jungle nightjar†
(M, Mx) Feb.-April. Identified by call, Kanha meadow, Bahmnidadar, Kodaidadar, Deotalao.

C. affinis Franklin's nightjar
(M, Salf) [w, B] Jan.-May, Kanha meadows. Calling March-April. 31/5/82, 2 eggs in depression in copse, Kanha meadow (PN).

APODIDAE

Chaetura sylvatica Whiterumped spinetail*
[W] Nov., Jan.-March. Flying above Kisli, Kanha & Sonph meadows.

Apus affinis House swift†
22/2/81, flying above Kanha anicut (GJN).

Hemiprocne longipennis Crested swift*†
[w] Dec.-June. Above Sulkum valley meadows and sal forests. 27/2/81, 2 copulated at top of tree (GJN).

ALCEDINIDAE

Alcedo atthis Common kingfisher†
(N, T) Dec.-June, Aug.-Oct. Common on nullahs & tanks in Sulkum valley, also at Deotalao. A Lesser pied kingfisher (*Ceryle rudis*) was observed at Kanha anicut in the cold weather of 1981/2, but the record was lost (PN).

Halcyon smyrnensis Whitebreasted kingfisher*†
(N, M, Salf, Salb, Mx) Jan.-Oct. Common throughout Sulkum valley.

H. pileata Blackcapped kingfisher
(N) 13/4/82, 25/4/82, 1 Desi nullah. Rarely recorded in central India on sporadic forays from coast, not previously recorded from M.P. (Ali & Ripley 1968-74).

MEROPIDAE

Merops philippinus Bluetailed bee-eater*
Recorded by Guntert & Homberger (1973) in September 1972 at Sonph & Kanha meadows.

M. orientalis Green bee-eater†
(M, Mx) [w, B] Oct.-June. Common throughout Sulkum valley. In 1981 left late June, first back 14/11/81. 9/5/82, 2/6/82, nests at Kisli (SB).

CORACIIDAE

Coracias benghalensis Indian roller*†
(M, Salf, Salb, Mx, D) [B] All months except Sept.-Nov. Common throughout Sulkum valley. 6/5/82, 13/5/82, adult feeding young at nests, Kanha meadow (SB).

UPUPIDAE

Upupa epops Hoopoe*†
(M, Salf, Mx) [w, B] Oct.-July. Kanha, Kisli, Sonph meadows, Deotalao. Calling Feb.-June, most frequently in February. 20/4/82, adult feeding nestlings, Kanha meadow (SB).

BUCEROTIDAE

Tockus birostris Common grey hornbill*†
(M, Salf, Mx) [w] Oct.-July. Common throughout Sulkum valley.

Anthracoceros coronatus Malabar pied hornbill†
(M, Salf, Salb, Mx) [w] Oct.-July. Common throughout Sulkum valley.

CAPITONIDAE

Megalaima zeylanica Green barbet*
(M, Salf, Salb, Mx) [B] Nov.-June, August. Common throughout Park. Feeding on *Ficus arnottiana* leaf buds in May and *F. tomentosa* figs in August (PN). 2/5/82, feeding young in hollow tree. 10/5/82, nest 3 eggs in dead tree 1.75 m up. May/82, a pair excavating nest 1.5 m up dead tree. All nests Kanha meadows (SB).

M. haemacephala Crimsonbreasted barbet*†
(M, Salf, Mx, D) Jan.-May, Aug., Oct. Kanha, Sonph, Kisli, Shrawanchitta.

PICIDAE

Micropternus brachyurus Rufous woodpecker*
(Salf) 12/10/81, 2/6/82, 17/6/82, Kanha meadow sal forest.

Picus myrmecophoneus Little scalybellied green woodpecker*
(M, Salf, Salb, Mx) [w] May, June, Nov., Feb. Kanha, Kisli, Bisanpura meadows.

P. chlorolophus Small yellownaped woodpecker*
Recorded by Guntert & Homberger (1973) on 9/9/72 at Sonph in sal forest, the first record for central India. This species occurs in the adjacent Western and Eastern Ghats (Ali & Ripley 1968-74).

Dinopium benghalense Lesser goldenbacked woodpecker*†
(M, Salf, Salb, Mx, D) All months except April, Sept., Nov. Kanha, Sonph, Kisli, Kodaidadar.

Picoides mahrattensis Yellowfronted pied woodpecker*
(Salb, Mx) [W] March-April. Kodaidadar, Kopedubri, Muchadonga.

P. nanus Pigmy woodpecker
(M, Salf, Salb, Mx, D) Jan.-March, May-Aug., Oct. Kanha, Kisli, Kodaidadar.

Chrysocolaptes festivus Blackbacked woodpecker*
(Salf, Mx) [w] Oct., Feb.-June. Kanha meadow, Kodaidadar. In May feeding on *Lannea coromandelica* fruit.

PITTIDAE

Pitta brachyura Indian pitta

(M, Salf) April-June, Aug. Solitaries Kanha & Bisanpura meadows. Perhaps passage migrants either side of the monsoon (Ali & Ripley 1968-74).

ALAUDIDAE

Mirafra assamica Bush lark

16/2/81, 1 on Kanha meadow (GJN).

Eremopterix grisea Ashycrowned finch-lark*†

(M) 6/3/81, on Rondha meadow (GJN). 11/10/82, 3 on track Kanha meadow (SB).

Ammomanes phoenicurus Rufoustailed finch-lark

(M) [w] June, July, Oct., Jan., Feb. Kanha, Sonph meadows.

Alauda gulgula Eastern skylark

(C) 19/6/80, common singing in pastureland near Indravangram, in buffer zone NE of Bilwani (PN). Not observed within Park.

HIRUNDINIDAE

Hirundo rustica Swallow†

[W] January 1981, numerous flying over Kanha anicut.

H. smithii Wiretailed swallow*

[w] Nov.-May. Kanha anicut, maximum numbers about 30 birds. 1st return 14/11/81.

H. fluvicola Indian cliff swallow†

Recorded by Panwar (n.d.).

H. daurica Redrumped swallow*†

[w] Dec.-June. Flying over Kanha, Sondh, Rondha meadows, particularly over water.

Delichon urbica House martin

[W] 6/3/82, flying over Desi anicut and Kanha meadow (PN). Also winter 1982/3 Kanha and Kisli meadows (SB).

LANIIDAE

Lanius excubitor Grey shrike†

(M) [W] Jan.-March. Kanha meadow, Bahmnidadar.

L. vittatus Baybacked shrike†

(M) 2/1/82, Kanha meadow (PN).

L. schach Rufousbacked shrike

(M) [W] Dec.-March. Kanha and Sonph meadows.

L. cristatus Brown shrike

(M, Salf, Salb) [w] Oct.-Dec., Feb.-March, May. Kanha village & meadow, Kisli, Sonph, Rondha meadows.

ORIOLIDAE

Oriolus oriolus Golden oriole*†

(M, Salf, Mx) [w,B] Jan.-June, Oct. Kanha, Kisli. 12/6/83, female building nest 15 m up sal tree, Kanha village.

O. xanthornus Blackheaded oriole*†

(M, Salf, Salb, Mx) [w, B] Dec.-July, Oct. Kanha, Sonph, Kisli, Kodaidadar. May 1981 feeding *Lannea coromandelica* fruit. 24/5/83, building nest 20 m up sal tree, Kanha meadows, 26/5/83, Indian cuckoo (*C. micropterus*) sat briefly on nest (SB).

DICRURIDAE

Dicrurus adsimilis Black drongo*†

(M, Salf, Salb) [w, B] Dec.-March, May. Kanha, Kisli and Sonph. Occasionally feeding on backs of barasingha (*Cervus duvauceli branderi*). 23/6/82, a pair feeding fledglings. 22/5/83, sitting on eggs. 12/6/83, pair feeding young at nest 27 m up sal; all nests on Kanha meadow (SB).

D. leucophaeus Grey drongo*

(M, Salf) [w] March-June, Kanha meadow.

D. caerulescens Whitebellied drongo*†
(Salf, Mx) Jan.-Aug., Oct. Kanha, Sonph, Kisli, Kodaidadar, Shrawanchitta, Deotalao.

D. hottentottus Haircrested drongo
(M, Salf, Salb, Mx) [w, B] Jan.-March, June, Nov. Kanha, Kisli & Sonph meadows. Most noticeable in March when birds feed at flowering *Bombax ceiba* trees, probably on nectar (PN). 6/6/82, pair with nesting material in Kisli sal forest (SB).

D. paradiseus Greater racket-tailed drongo*†
(Salf, Salb, Mx) Jan.-March, July, Aug., Oct., Nov. Kanha, Kisli, Kodaidadar, Kerighat.

ARTAMIDAE

Artamus fuscus Ashy swallow-shrike†
Recorded by Panwar (n.d.).

STURNIDAE

Sturnus malabaricus Greyheaded myna
(M, Salf, Salb, Mx) [w, B] Feb.-June. Kanha, Kisli meadows. In May, 30 bathing in Desi nullah. Feb.-March frequently feeding at flowering *B. ceiba* trees. 29/6/81, adults feeding 3 fledglings at Kanha (SB).

S. pagodarum Brahminy myna†
(M) [w] Feb.-June. Kanha & Silpura meadows. Feb.-March frequently feeding at flowering *B. ceiba* (PN).

S. roseus Rosy pastor
(M) 12/3/81, 1 in flowering *Bombax ceiba,* Kanha meadow (GJN).

S. contra Pied myna*†
(M) [w] May-July, Oct., Dec.-March. Kanha, Sonph meadows. Feb.-March frequently feeding at flowering *B. ceiba* (PN).

Acridotheres tristis Common myna*†
(M, Salf, Salb, Mx, D) Jan.-Aug., Oct., Nov. Kanha & Kisli villages and meadows, Chuchi mutta, Sonph meadows. In May feeding on *Lannea coromandelica* fruits. Commonly observed perching on and feeding from chital (*Axis axis*), barasingha (*C. d. branderi*), blackbuck (*Antilope cervicapra*).

A. ginginianus Bank myna*
1 caught by Guntert & Homberger (1973), 17/9/72 at Desi nullah.

A. fuscus Jungle myna†
(M, Salf) [w] March, May, June. Kanha, Sonph & Silpura meadows. In May feeding *Syzygium cumini* fruit and in March at flowering *B. ceiba* (PN).

CORVIDAE

Dendrocitta vagabunda Indian tree pie*†
(M, Salf, Salb, Mx, D) Nov.-Aug. Common throughout Park. 14/2/82, hammering at tussar moth cocoon, in May feeding *Lannea coromandelica* fruit.

Corvus splendens House crow*†
(M, Salf) [R] All months. Kanha & Kisli villages, occasionally in surrounding sal forest.

C. macrorhynchos Jungle crow*†
(M, Salf, Salb, Mx) [B] Dec.-March, May, June, Aug., Oct. Common throughout Park. In March feeding at flowering *B. ceiba.* Common scavengers at ungulate carcases. 2/5/82, nest with fledglings, Menhar bund (SB).

CAMPEPHAGIDAE

Hemipus picatus Pied flycatcher-shrike
(Mx) 10/3/81, Kodai dadar. 13/3/81, Kanha ghat. 4/3/82, Shrawanchitta 6/3/82, Mundri dadar. 13/5/83, Churi nullah. All in dense bamboo thickets.

Tephrodornis pondicerianus Common wood shrike*
(M, Salf, Salb, Mx, D) Feb.-April, July-Aug., Oct. Kanha, Kisli, Kodaidadar, Shrawanchitta.

Coracina novaehollandiae Large cuckoo-shrike*
(M, Salf, Salb, Mx) Jan.-June, Aug., Oct. Kanha, Kisli, Kodaidadar.

C. melanoptera Blackheaded cuckoo-shrike (M) 24/3/80, 1 feeding at *Butea monosperma* flowers, Menhar bund, Kanha meadow (PN).

Pericrocotus flammeus Scarlet minivet*† (Salf, Salb, Mx) All months except Sept. Common in sal canopies in Sulkum valley. Also in hills at Deotalao, Kodaidadar & Bijadadar.

P. roseus Rosy minivet (Salf, Salb) [B] 6/3/81, 10/3/81, 20/5/83 Kanha meadows. 20/5/83, gathering nest material (SB). Ali & Ripley (1968-74) do not record this species breeding in central India, nor remaining beyond April.

P. cinnamomeus Small minivet* (M, Salf, Salb, Mx) Jan.-May, Aug., Oct. Common in sal canopies in Sulkum valley.

IRENIDAE

Aegithina tiphia Common iora* (M, Salf, Salb, Mx) [w] Oct.-June. Common throughout Sulkum valley.

Chloropsis aurifrons Goldenfronted chloropsis* (M, Salf, Salb, Mx) Dec.-May, Aug., Oct. Kanha, Kisli. In Feb.-March feeding at flowering *Bombax ceiba* (PN).

C. cochinchinensis Goldmantled chloropsis (Salf, Mx) [W] Dec.-March. Kanha, Kodaidadar.

PYCNONOTIDAE

Pycnonotus jocosus Redwhiskered bulbul* (Mx) 30/4/82, small flock at Shrawanchitta.

P. cafer Redvented bulbul*† (M, Salf, Salb, Mx) [B] Oct.-Aug. Common throughout Park. In May feeding on *Lannea coromandelica* fruits. 23/5/83, nest building in sal tree, 10 m up, Kanha meadow (SB).

MUSCICAPIDAE

Pellorneum ruficeps Spotted babbler* (Salb, Mx) [w] March, April, June. Brhoindubra, Churi & Sulkum nullahs.

Pomatorhinus horsfieldii Slatyheaded scimitar babbler* (Salb, Mx) [w] Nov., Feb.-March, May, June. In dense bamboo tracts Kisli, Kanha, Kodaidadar and bordering Sulkum nullah.

Dumetia hyperythra Rufousbellied babbler* (M, Salf, Salb, Mx) [w] Oct.-July. Kanha, Sonph, Kodaidadar & Bisanpura, particularly in bamboo.

Chrysomma sinense Yelloweyed babbler* (M, Salf, Salb, Mx) All months except Sept. Kanha, Sonph, particularly in tall grass bordering nullahs.

Turdoides malcolmi Large grey babbler† Recorded by Panwar (n.d.).

T. striatus Jungle babbler*† (M, Salf, Salb, Mx) [w, B] Oct.-April. Common throughout the Park. 15/6/82, building nest Kanha meadow (SB).

Alcippe poioicephala Quaker babbler (Salf, Salb, Mx) [w] Oct.-Nov., Feb.-May. Kanha, Kisli, Kodaidadar, Kulughat, Kopedubri, Mahadeo gogra.

Muscicapa muttui Brownbreasted flycatcher (Salb) 25/11/82, 1 at Kopedubri (SB).

M. parva Redbreasted flycatcher (Salf, Salb, Mx) [W] Oct.-March. Common throughout Sulkum valley. 1st return 12/10/81 with a marked decline from late February.

M. superciliaris Whitebrowed blue flycatcher (M, Salf, Salb, Mx) [W] Nov.-March. Kanha, Kisli, Kodaidadar.

M. tickelliae Tickell's blue flycatcher* (M, Salf, Salb, Mx) [w] Oct.-May. Kanha, Kisli, Bahmnidadar, Kodaidadar, Mahadeo gogra.

M. thalassina Verditer flycatcher
(Salb, Mx) [W] 9/2/81, 13/3/81, 19/11/81. Kanha, Kisli, Bahmnidadar.

Culicicapa ceylonensis Greyheaded flycatcher
(Salf, Salb, Mx) [W] Nov.-March. Kanha, Kisli, Bahmnidadar, Kerighat, Chhindi Pathar. 1st return 9/11/81.

Rhipidura aureola Whitebrowed fantail flycatcher
(M, Salf, Salb, Mx) [W] Feb.-April. Kanha, Kisli, Bahmnidadar, Deotalao.

R. albicollis Whitethroated fantail flycatcher
(Mx) 4/3/82, 1 in dense bamboo, Shrawanchitta (PN).

Terpsiphone paradisi Paradise flycatcher*
(M, Salf) May, June, Jan. Kanha meadow. Guntert & Homberger (1973) noted 2 in Sept. 1972.

Hypothymis azurea Blacknaped flycatcher*
(M, Salf, Salb, Mx) [w] Oct.-June. Common throughout Sulkum valley.

Cisticola juncidis Streaked fantail warbler*†
(M) [w, B] Jan.-March, June, July. Common in Kanha, Sonph meadows. 18/7/83, nest 4 eggs 1 m up in grass clump, Kanha meadow (SB).

Prinia hodgsonii Franklin's wren-wrabler*
(M, Salf, Salb, Mx) [w] Jan.-June, Oct., Nov. Kanha, Kisli, Sonph, Kopedubri, Kodaidadar.

P. subflava Plain wren-warbler*†
(M) [W] Nov., Jan.-March. Kanha, Kopedubri in reedy areas, particularly nullah banks.

P. socialis Ashy wren-warbler*†
(M, Mx) [w, B] Jan.-March, May-July, Oct. Reedy areas, nullah banks throughout Sulkum valley. 10/7/82, nest 4 young in grass in bed of Sulkum nullah (SB).

P. sylvatica Jungle wren-warbler
(M, Salf, Salb, Mx) March. Kanha, Kodaidadar, in reedy habitats.

Orthotomus sutorius Tailor bird*
(M, Salf, Salb, Mx) [B] Dec.-June, Aug. Common throughout Sulkum valley. 2/6/82, nest 1 m up in hedge, 4 chicks, Kanha village (SB).

Sylvia curruca Lesser whitethroat
(Salf) 16/3/81, Kanha village (SB).

Phylloscopus collybita Brown leaf warbler
(Salb, Mx) [W] March, November. Kanha, Kodaidadar, Kisli.

P. affinis Tickell's leaf warbler
(Mx) [w] Dec.-June. Small parties in mixed forest (SB).

P. trochiloides Dull green leaf warbler
(Mx) [w] Dec.-June. Small parties in mixed forest (SB).

Erithacus calliope Rubythroat
(M) 9/10/81, 1 in tall grass meadow, Churi nullah (PN).

E. svecicus Bluethroat
(M) 25/2/81, 6/3/81 pairs at Kanha, Rondha meadows (GJN).

Copsychus saularis Magpie-robin*
(M, Salf, Salb, Mx) [w] Nov., Jan.-July. Common throughout Sulkum valley. Singing March, April & June. 1st return 14/1/82.

C. malabaricus Shama
(Salb, Mx) [w] Jan.-June, Oct., Nov. In bamboo areas of Kodaidadar, Kanhaghat, Deotalao, Mahadeo gogra. Singing March, April, Oct. & Jan.

Phoenicurus ochruros Black redstart
(M, Salf, Salb, Mx) [W] Jan.-March, Nov. Kanha, Kisli, Sonph, common around Kanha resthouses. 1st return 28/11/81 and 9/11/82.

Saxicola torquata Stone chat*
(M, Salb) [w] Oct.-July. Common throughout Sulkum valley, especially Kanha, Rondha, Sonph meadows. 1st return 12/10/81.

S. caprata Pied bush chat*†
(M) [w] Jan.-March, June, July, Oct., Nov. Common on Kanha, Sonph meadows, especially in patches of tall grass. Singing in March. 1st return 14/11/81 and 4/10/82.

S. ferrea Dark-grey bush chat

(M) Clearly observed on seven occasions 25/1/81-8/3/81 & 2/1/82 on meadows near Kanha anicut and in small meadow within sal forest with *Flemingia* undergrowth, beside Kanha-Sonph track, 5 km N of Kanha, altitude 1800′. Discovered by GJN. Description of female 2/1/82: "stonechat-like in size and behaviour, back brown, rufous rump, dark upper tail with rufous outer tail feathers, a bright white throat, dull greyish breast and chest, head grey with faint grey supercilium". Ripley (1982) states that this species overwinters south to the Gangetic plain (Yumuna river); no previous records from central India published.

Saxicoloides fulicata Indian robin*

(M) 5/3/81, 3/4/82, Kanha meadow. Singing in April.

M. cinclorhynchus Blueheaded rock thrush

(Salf, Mx) [W] Jan., March. Kanha, Shrawanchitta.

M. solitarius Blue rock thrush

(Salb) 9/2/81, 29/3/81, Kanha, Bahmnidadar (GJN).

Zoothera citrina Orangeheaded ground thrush

(Salf, Salb, Mx) [w] Feb.-June. Churi nullah and in hills surrounding Sulkum valley. Common on ground in dense bamboo.

Turdus merula Blackbird

(Mx) 9/4/82, 30/4/82, Muchadonga, Kulughat & Mahadeo gogra. A bird found dead 23/4/82 on Chhindi Pathar identified by Dr. Salim Ali (B.N.H.S. Specimen No. 26314) as *T. m. nigropileus.*

PARIDAE

Parus major Grey tit*†

(M, Salf, Salb, Mx, D) All months except July, Sept. Common throughout Sulkum valley.

P. xanthogenys Yellowcheeked tit*

(M, Salf, Salb, Mx) [B] All months except Sept. Common throughout Sulkum valley. 10/5/82, pair nest building in hollow tree 7 m up, Morcha village (SB).

SITTIDAE

Sitta castanea Chestnutbellied nuthatch*†

(Salf) [w] Oct., Nov., Jan., March-June. Kanha meadow.

S. frontalis Velvetfronted nuthatch*

(Salf, Mx) [w] Nov.-April, June, Oct. Kanha, Sonph, Deotalao, Bijadadar.

MOTACILLIDAE

Anthus hodgsoni Indian tree pipit

(Salf, Mx) [w] Oct.-March. Kanha, Kodaidadar. Flocks of up to 30-50 common in forest. 1st return 28/10/81. Confusion with *Anthus trivialis* possible.

A. novaeseelandiae Paddyfield pipit†

(M) [w, B] Feb.-July. Common pipit on Kanha, Rondha, Sonph, Kisli meadows. 18/7/83, nest, 3 young, Kanha meadow (SB).

A. campestris Tawny pipit

(M) 17/11/82, 1 Kanha meadow (SB).

Motacilla citreola Yellowheaded wagtail

(M, Salf) [W] March. Kanha, Sonph, on nullah banks.

M. cinerea Grey wagtail*†

(M) [w] Jan.-March, April, May, Oct. Kanha, Sonph, Kerighat, Deotalao particularly near water.

M. alba White wagtail†

(M, Mx) [W] Jan.-March, Oct. Kanha.

M. maderaspatensis Large pied wagtail†

(N) 27/2/80, 1 foraging among boulders, Banjar nullah, Mukki (PN).

DICAEIDAE

Dicaeum agile Thickbilled flowerpecker*

(Salf, B) [W, B] March, May, Oct. Kanha, Mucha. 2/5/82, nest 2.5 m up tree, 3 eggs, at Morcha village (SB).

D. erythrorhynchos Tickell's flowerpecker
(Salf, Mx) [W] Jan.-March. Kodaidadar, Kanha, Jan./82 feeding at flowering *Woodfordia fruticosa* (PN).

NECTARINIIDAE

Nectarinia asiatica Purple sunbird†
(M, Salf, Salb, Mx) [w, B] Jan.-May. Common throughout Sulkum valley. Singing Feb. 5/3/81, building nest in overhanging roots, nullah bank, 18/3/81, 3 eggs (GJN). 21/4/82, female nest building in bamboo, Kanha meadow, 25/4/82, with 1 egg. 5/5/82, 2 eggs in nest, Kisli (SB). 7/3/82, feeding at flowering *W. fruticosa* (PN).

ZOSTEROPIDAE

Zosterops palpebrosa White eye*
(M, Salf, Salb, Mx) Nov.-March, April-Aug. Common throughout Sulkum valley. 7/3/82, feeding at flowering *Woodfordia fruticosa.*

PLOCEIDAE

Passer domesticus House sparrow
(C) [R, B] All months at Kanha village and in buffer zone. 26/1/81, nesting under eaves of house (GJN). Not found in forest away from villages.

Petronia xanthocollis Yellowthroated sparrow
(M, Salb, Mx) [W] Oct., Feb.-April. Common throughout Sulkum valley. 1st return 19/2/82. Singing in March.

Ploceus philippinus Baya
(C) 18/7/83, 3 breeding colonies at Morcha village in buffer zone (SB), not noted within Park.

Estrilda amandava Red munia
(M) [w] Nov., Feb.-April, June. Kanha, Sonph meadows, especially on burnt ground.

E. formosa Green munia*
1 male recorded by Guntert & Homberger (1973) at Churi nullah 18/9/72.

Lonchura striata Whitebacked munia*
(M) [W, B] Dec., Feb.-April. Kanha meadow. 1/3/81, carrying nesting material (GJN).

L. punctulata Spotted munia*†
(M) June-Aug., Oct., Nov. Kanha meadow, flocks of about 20 feeding in nullah grassland.

L. malacca Blackheaded munia*
(M, Mx) [w] Oct.-March, June, July. Kanha, Beniphat, Shrawanchitta, Kopedubri.

FRINGILLIDAE

Carpodacus erythrinus Common rosefinch
(M, Mx) [W] Oct.-Nov., Feb.-March. Kanha, Kodaidadar, Shrawanchitta. Flocks of about 50 common on meadows and in bamboo. 1st return 12/10/81.

EMBERIZIDAE

Melophus lathami Crested bunting
(M) 8/10/82, 1 male Kanha meadow (SB).

DISCUSSION

Including the observations of Panwar (n.d.), Guntert & Homberger (1973), Anderson (1979) and Ranjitsinh (1983) 225 species of bird have been recorded from Kanha Tiger Reserve. This is, undoubtedly an underestimate. Our records were collected opportunistically, during our major work, and fieldwork was concentrated in the valleys with relatively little time spent in the hills or buffer zone.

Of the 77 families of Indian birds (Ripley 1982), 52 have been recorded in Kanha. The avifauna was dominated by members of the Muscicapidae (40 species) and Accipitridae (14 species). The best birdwatching sites, in terms of number of species seen, were Churi nullah (to Beniphat machan), Kanha anicut,

TABLE 1

BIRD SPECIES, OBSERVED IN KANHA TIGER RESERVE, NOT RECORDED IN THE CENTRAL PROVINCES BY D'ABREU (1935) [*] OR IN MADHYA PRADESH BY HEWETSON (1955) [†]

shag	*P. fuscicollis**†
black stork	*C. nigra**†
wigeon	*A. penelope**†
pied harrier	*C. melanoleucos*†
bluebreasted banded rail	*R. striatus**
Baillon's crake	*P. pusilla*†
brown crake	*A. akool*†
spotted redshank	*T. erythropus**†
Indian banded bay cuckoo	*C. sonneratii*†
barn owl	*T. alba*†
brown hawk-owl	*N. scutulata*†
shorteared owl	*A. flammeus*†
Franklin's nightjar	*C. affinis*†
whiterumped spinetail	*C. sylvatica*†
blackcapped kingfisher	*H. pileata**†
house martin	*D. urbica*†
jungle myna	*A. fuscus**
rosy minivet	*P. roseus*†
brownbreasted flycatcher	*M. muttui**†
Franklin's wren-warbler	*P. hodgsonii**†
Tickell's leaf warbler	*P. affinis**†
dull green leaf warbler	*P. trochiloides*†
rubythroat	*E. calliope*†
dark-grey bush chat	*S. ferrea**†
Indian tree pipit	*A. hodgsoni**

Chhindi Pathar, Kodaidadar, Sonph meadow and Sulcum nullah. The 'chattans', boulder-strewn hillocks, vegetated with dry deciduous forest amidst sal forest, were particularly rich islands of bird diversity.

The observations of dark-grey bush chat (*S. ferrea*) are of particular interest as this species has not been previously reported in M.P. or south of the Gangetic plain (Ali & Ripley 1968-74). The records suggest that it may be a winter visitor to Kanha. The black-capped kingfisher (*H. pileata*), although known to make sporadic forays inland from the coast, does not appear to have been previously recorded in M.P. As it was observed only in April 1982 it may have been an unusual vagrant. Other interesting observations include the golden-fronted chloropsis (*C. aurifrons*), rare in central India (Ali & Ripley 1968-74), but recorded by Hewetson (1955) in M.P. The rosy minivet (*P. roseus*) is a sporadic winter visitor to central India (Ali & Ripley 1968-74) but records after April, or of breeding, have not been previously reported. Therefore, the observation of a bird gathering nest material in late May suggests that the species may breed and not be just a winter visitor. Other unusual species recorded were the black stork (*C. nigra*), rubythroat (*E. calliope*) and, by Ranjitsinh (1983), the lesser florican (*S. indica*). The observation of emerald dove (*C. indica*) supports Hewetson's (1955) suggestion of a colony on the Mandla/Balaghat border, isolated from other populations.

Species recorded here, but not mentioned in D'Abreu (1935) or Hewetson (1955) are given in Table 1. D'Abreu (1935) also recorded the following eight species in Mandla and/or Balaghat Districts which have not yet been noted in Kanha; wood snipe (*G. nemoricola*), painted bush quail (*P. erythrorhyncha*), stork-billed kingfisher (*P. capensis*), grass owl (*T. capensis*), fantail warbler (*C. exilis*), olivaceous leaf warbler (*P. griseolus*), plain leaf warbler (*P. inornatus*) and yellow-backed sunbird (*A. siparaja*).

Our records of breeding and migration are incomplete but those obtained agree with the data given in Ali & Ripley (1968-74). The observations of residents, which by definition had to be noted in every month of the year, were particularly scanty. Monthly lists of species present, in the manner of Hewetson (1939), were not constructed. Seasonal change in the avifauna was also complicated by a low intensity of fieldwork in September due to illness.

Only 11 species were classified as residents, 33 as winter visitors and 65 as winter & summer visitors. Breeding within the Park was recorded for 27 species. Of 49 breeding records, confined to January to July, October and November, all but five were obtained from April to July, reaching a peak in May. Most species remained unclassified due to a shortage of data and further fieldwork is required to clarify their migratory and breeding status. The influx of winter visitors and exodus of both species and individuals during the monsoon was pronounced and no species increased in abundance during the monsoon. The only species which did not appear to decline in numbers during this season was the white-backed vulture (*G. bengalensis*). This suggests that many species immigrate during the winter, some departing with the onset of the hot weather, with others breeding and departing with the break of the rains. For those species resident, the fall in numbers during the monsoon suggests that some of the population moves in and out of the Reserve depending on environmental conditions. The migratory status of species will depend on the geographical area being considered, i.e. local movements within the Maikal Hills will be, to an observer confined to Kanha, indistinguishable from long range migration between the Himalayas and the Reserve. Caution must also be exercised in inferring a seasonal pattern from just two years data. However, the pied crested cuckoo (*C. jacobinus*), pitta (*P. brachyura*) and the blueheaded rock thrush (*M. cinclorhynchus*) all appeared regularly, but briefly, in different years, suggesting that they are passage migrants, in agreement with Ali & Ripley (1968-74).

A striking aspect of the ecology of Kanha birds was their frequent participation in mixed flocks. In 26 such flocks, whose composition was recorded, 35 species were represented [a mean of 5 species/flock ± S.D. 2.5 (range 2-12)]. The species which participated most frequently are listed in Table 2.

Aside from changes in climate and vegetation in geological time (cf 'Satpura Hypothesis'; Ali & Ripley 1968-74), the Kanha avifauna has probably been considerably altered by human influence; its remoteness and wildness is, in part, deceptive. All the open water bodies are, at least in their present form, manmade, inflating considerably the species richness and population size of waterbirds. Up to the turn of the century the predominant human influence was through the hunting, gathering and slash-and-burn cultivation of the Baiga forest tribe. This 'bewar' cultivation

TABLE 2

FREQUENCY OF SPECIES OCCURRENCE IN 26 MIXED FLOCKS. SPECIES OBSERVED IN LESS THAN 5 FLOCKS ARE NOT LISTED

Species		No. of occurrences
yellow-cheeked tit	*P. xanthogenys*	15
grey tit	*P. major*	13
black-naped flycatcher	*H. azurea*	9
white eye	*Z. palpebrosa*	8
small minivet	*P. cinnamomeus*	7
scarlet minivet	*P. flammeus*	7
iora	*A. tiphia*	6
whitebellied drongo	*D. caerulescens*	5
velvetfronted nuthatch	*S. frontalis*	5
tailor bird	*O. sutorius*	5

fragmented the sal forest with meadows, increasing habitat diversity and the abundance of ecotones, with probably profound affects on the bird fauna. More recently the human influence has shifted to that of the Forest Department, whose prime effect on the bird population has probably been, aside from the cessation of logging, the prevention of the vast destructive forest fires described by Forsyth (1872) and Brander (1906). Therefore, human influence has, so far, probably increased bird species diversity within the Park.

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IMMOBILIZING GAUR WITH AN ETORPHINE AND TRANQUILIZER MIXTURE[1]

PAUL J. CONRY[2]

Eight free-ranging Malayan gaur were immobilized with an etorphine and tranquilizer mixture. Three different combinations of drugs successfully immobilized gaur; Immobilon (etorphine + acepromazine), Immobilon + Azaperone, and Immobilon + Rompun (xylazine). Effective doses of etorphine ranged from 2.45 mg on a calf to 9.8 mg on an adult bull. Using body weight estimates to compute dosage rates, the median dosage of etorphine was 1.58 mg/100 kg and varied from 0.98 to 2.45 mg/100 kg. The Immobilon-Rompun combination performed better than the Immobilon-azaperone combination in these limited field trials. The addition of 150 mg of xylazine to the combination provided a calming effect and a smooth transition out of narcosis. Darting failures of adult animals were a problem in this study and appeared to be caused by underdosing. The problem should be easily resolved by simply increasing the dose of etorphine to 10.0 to 12.0 mg for adult animals. The wide safety margin and safety net effect of the etorphine-xylazine mixture, when used with the antagonist diprenorphine, made a particularly appropriate drug combination to capture gaur in the rain forest environment. Field personnel using etorphine should be aware of the human risk involved and be adequately trained and equipped to deal with an accidental administration into a human.

INTRODUCTION

The Malayan gaur or seladang (*Bos gaurus hubbacki*) is a member of the wild cattle group found in the tropical evergreen rain forests of Malaysia and Southwest Thailand. Human disturbance and habitat modification associated with the recent extensive development of the lowland rain forests have caused a decline in gaur numbers throughout its range (Stevens 1968, Simon 1969, Lekagul and McNeely 1977, Conry 1980). Interest in the conservation and management of the animal led to a field study of gaur ecology in central Pahang, Malaysia, during 1976-1979. One objective of that study was to determine home range, movements, and habitat use of gaur which involved immobilizing free-ranging animals to attach radio-telemetry collars. The purposes of this note are to report the immobilization of free-ranging gaur and provide information on drug combinations and dosages. With the continued critical status of the gaur throughout most of its range, this information may prove useful in efforts to capture animals for further research or to obtain stock for captive breeding efforts.

METHODS

Large Animal Immobilon (2.45 mg etorphine hydrochloride + 10.0 mg Acepromazine Maleate/ml; Reckitt and Coleman Pharmaceutical Division, Hull, England) was used singly or in combination with Rompun (xylazine

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hydrochloride; Bayer, Leverkusen, Germany) or Azaperone (azaperone; Janssen Pharmaceutica, Beerse, Belgium) to immobilize free-ranging gaur. Capture teams composed of the author and wildlife rangers or a ranger team darted animals from the ground with Palmer Cap-chur guns and 4 or 7 cc darts equiped with collared needles (Palmer Chemical and Equipment Co., Inc.). Most animals were darted in the hindquarter or shoulder. The immobilized animals were treated with medications, measured, and radio-collared (if appropriate) prior to the intravenous injection (ear vein) of the etorphine antagonist Revivon (3.0 mg diprenorphine hydrochloride/ml; Reckitt and Coleman Pharmaceutical Division). Body weights of immobilized animals were estimated with a domestic cattle chest-circumference/body-weight tape.

RESULTS

Eight gaur were successfully immobilized with etorphine combined with a tranquilizer (Table 1). Effective drug doses ranged from 2.45 mg etorphine combined with 10.0 mg acepromazine and 100 mg azaperone, used on a calf (No. 1F), to 9.8 mg etorphine combined with 40.0 mg acepromazine and 500 mg xylazine, used on an adult bull (No. 9M). The median dose of etorphine was 6.13 mg. Using body weight estimates to compute dosage rates, the median dosage of etorphine was 1.58 mg/100 kg (range 0.98-2.45 mg/100 kg).

Seven gaur darted did not go down. Five spent darts were recovered from the forest floor, 4 appeared to have functioned properly. In 2 instances, darted animals were resighted and partial responses to the drugs observed as the animals fled.

In unsuccessful attempts, doses of etorphine varied from 4.9 to 8.58 mg (median dose = 6.13 combined with from 20.0 to 35.0 mg acepromazine) with either xylazine or azaperone added as a tranquilizer (Table 2). Based

TABLE 1

DRUGS/DOSES ADMINISTERED AND REACTION TIMES OF FREE-RANGING MALAYAN GAUR SUCCESSFULLY IMMOBILIZED WITH ETORPHINE AND TRANQUILIZER MIXTURES

No./ Sex	Dose (mg)				Wt (kg)	Dosage etorphine (mg/ 100 Kg)	Reaction time[1]	
	Etorphine/ Acepromazine	Xylazine	Azaperone	Diprenorphine			F	R
1M	2.45/10.0		100	3.0	100	2.45		
5F	9.8/40.0			12.0	600	1.63		
6F[2]	9.8/40.0		300	13.5	700	1.4	5	
7F	4.9/20.0	150		7.5	250	1.96	10	5
9M[3]	9.8/40.0	500		12.0	950	1.03	90	10
10M	6.13/25.0	150		7.5	400	1.53	15	4
11M	4.9/20.0	150		6.0	500	0.98	25	4
12M	6.13/25.0	150		7.5	300	2.04	5	5

[1] Reaction time: F = time to find, R = recovery time, in minutes.

[2] Animal remained recumbent following immobilization and died after 8 days.

[3] Includes a second dose of 2.45 mg etorphine/10.0 mg Acepromazine and 300 mg xylazine.

Table 2

Drugs/doses administered in unsuccessful imobilizations of free-ranging Malayan gaur

No/Sex	Dose (mg)			Size estimate	Notes on dart function
	Etorphine/ Acepromazine	Xylazine	Azaperone		
2M	4.9/20.0		100	Lg adult	drug ejected
3M	8.58/35.0		50	Lg adult	drug ejected
4	6.13/25.0		50	Subadult	drug ejected
8F	6.13/25.0	150		Adult	drug ejected
13F	4.9/20.0	150		Adult	not recovered
14F	6.13/25.0	150		Adult	not recovered
15M	7.35/30.0	250		Lg adult	drug ejected, needle broken

on visual appraisal of animal size, all but 1 of the animals that failed to go down when darted were moderate to large size adults.

The "time to find", defined as the period between drug injection and location of the immobilized animal, provided a maximum value measure of induction time with actual induction time equal to or less than "time to find." The "time to find" was recorded for 6 cases and varied from 5 to 90 minutes (Table 1). The 90 minute case occurred when an adult bull was not fully immobilized and fled more than 1.6 km before becoming entangled in vines. A second dose of etorphine was administered and the bull was fully immobilized at 90 minutes. Excluding the 90 minute case, the mean "time to find" was 12 minutes (n=5).

The narcosis stage allowed easy handling of the animals and was of sufficient length for thorough processing of each animal. The mean down time was 42 minutes (range 35-45, n=6).

The manufacturer's recommended dosage of 1.0 ml Revivon per 1.0 ml Immobilon was administered intravenously to the 8 immobilized gaur. With 1 exception, all animals recovered quickly; mean recovery time was 5.6 minutes (range 4-10). A large dose of xylazine (500 mg) apparently delayed the recovery of animal No. 9M. Recovery time was twice that of the other animals, and on standing, it had wobbly legs and moved off only 300 m before bedding down. Subsequent sightings indicated that the animal fully recovered.

One animal died during the capture operation. An old cow estimated at over 15 years of age was darted with a large dose (9.8 mg etorphine combined with 40.0 mg acepromazine and 300 mg azaperone) and found immobilized at 5 minutes. After working on the animal 35 minutes, the etorphine antagonist was given intravenously and signs of recovery detected at 10 minutes. Once revived, the animal stood for a few minutes on wobbly legs, then laid back down. After an additional feeble effort the next day, it remained recumbent and died 8 days later. A veterinarian examined the recumbent animal but detected no medical malady or abnormality other than advanced age and the stress associated with capture.

Discussion

Although chemical immobilization of free-ranging wild animals was common in

Africa and North America at the time of this study, the technique was still in the initial trial stages in Southeast Asia. In Malaysia, Weigum (1972) had little success immobilizing gaur in early field tests with a powdered form of etorphine hydrochloride. More recently, Olivier (1978) immobilized free-ranging elephants (*Elephas maximus*) from the ground and Williams (1978) immobilized tapir (*Tapirus indicus*) captured in a corral trap with an etorphine/tranquilizer mixture. Thus, the immobilization efforts in this study relied a great deal on initial trial and error experience.

In selecting the drugs with which to capture gaur, the tropical rain forest environment placed a number of limitations on capture operations and stringent requirements on the performance of immobilizing drugs. The tall, dense forest cover excluded aerial capture operations and necessitated darting from the ground, usually on foot. Ground darting free-ranging animals in dense vegetation required a fast-acting drug to minimize distance moved and therefore increase the ease of finding a darted animal. In addition, the high mean annual temperatures made prolonged immobilization risky, thus, an immobilizing drug with a reversal agent was appropriate. Immobilon was selected as the principal immobilizing drug because it had the desired attributes of fast action, reversibility, and neuroleptic effect and was readily available. Following Harthoorn's (1976: 255) recommendation, an additional tranquilizer was added to the Immobilon to counteract the excitement response common with etorphine.

Three different combinations of drugs successfully immobilized gaur; Immobilon (etorphine + acepromazine) used singly or combined with the tranquilizer azaperone or Rompun (xylazine). Initial immobilization efforts utilized an Immobilon-Azaperone combination with mixed results; an initial success (No. 1M), three unsuccessful attempts (Nos. 2M, 3M, 4), and a fatality (No. 6F). The poor success obtained with the Immobilon-Azaperone mixture and the fatality prompted a change to the Immobilon-Rompun mixture with improved success; five successful attempts out of nine. Based on my limited initial experience, the Immobilon-Rompun mixture appeared to be the better of the two.

With seven unsuccessful darting attempts, darting failures were a problem in this study. Underdosing was the known cause in two cases and the suspected cause in the other five. However, in one instance, a spent dart was recovered with a broken needle suggesting that the needle may have been broken colliding with brush and the drug ejected prior to impact with the animal. Gasaway *et al.* (1978) cautioned against attributing all immobilization failures to inadequate drug doses when they found that a large proportion of their darting failures were caused by dart malfunction, as may have been the case here. Nevertheless, underdosing was the probable cause in the remaining instances.

Weigum (1972) also experienced underdosing problems in his attempts to immobilize gaur in the 1960's. Using etorphine alone, he tried doses of 1.5-3.0 mg with no apparent effect, and an 8.0 mg dose knocked down a young bull, but narcosis was insufficient to allow handling. Weigum observed the excitement stage typical with etorphine and suggested adding a tranquilizer to obtain better results.

In comparing unsuccessful with successful dartings in this study, most unsuccessful efforts attempted to capture large animals with intermediate doses of etorphine (4.9 to 7.35 mg), whereas in successful efforts, large animals were usually immobilized with a 9.8 mg dose of etorphine. On similar sized animals, unsuccessful efforts used smaller doses of etorphine than successful dartings suggesting that underdosing was involved.

Doses of etorphine in some successful immobilizations may have been light as well, possibly right at the effective threshold, for most successful dosages were well below the 2.45 mg/100 kg dosage rate recommended by the manufacturer (Immobilon Package Insert). A dosage rate as little as 0.98 mg/100 kg, 40% of the recommended dosage, successfully immobilized number 11M. In retrospect, using small doses of etorphine as a precaution to avoid overdosing fatalities probably resulted in dosing light in some successful immobilizations and underdosing in most unsuccessful attempts.

The success of the light dosages in immobilizing gaur undoubtedly resulted from a synergistic effect obtained by adding xylazine as a tranquilizer in the mixture. Presnell *et al.* (1973) observed a similar effect immobilizing white-tailed deer (*Odocoileus virginianus*). They were able to use half the recommended dose of etorphine when combined with xylazine. Harthoorn (1976: 255) likewise stated that the efficacy of etorphine was greatly increased by combining it with tranquilizing agents such as xylazine. As xylazine is a particularly effective sedative-analgesic for domestic cattle, it appears to have a similar potent effect on the gaur as well. The residual tranquilizing effect obtained with xylazine in the drug mixture also provided a smooth transition out of narcosis when the etorphine antagonist was administered.

The etorphine-xylazine drug mixture, when used with the antagonist diprenorphine to reverse the action of the etorphine if an animal got in trouble, was a particularly appropriate choice for use on the gaur in a rain forest environment. The wide safety margin of etorphine (Harthoorn 1976: 255) combined with the reversibility of its action via the diprenorphine provided the safety net effect essential to capture rare and valuable animals such as the gaur. In one instance, dense vegetation and difficult tracking conditions delayed locating a darted animal for 90 minutes, yet the extended period of narcosis had no ill effect. The safety and effectiveness of the combination are such that it is commonly used in routine immobilizations of captive zoo populations of Indian gaur (*B. g. gaurus*) (J. Jensen, D.V.M., Oklahoma City Zoo, pers. commun.). In field trials in this study, animals under narcosis retained essential body functions, respiration remained rhythmic and adequate, and temperature regulation appeared unimpaired.

The problem of darting failures of large animals can probably be overcome simply by increasing the etorphine dose to 10.0-12.0 mg for adult animals. The addition of a 150 mg dose of xylazine to the mixture appears adequate to combat the excitability of the etorphine and provides a smooth transition out of narcosis. Such doses are not expected to increase drugging mortalities because of the wide safety margin of etorphine and the safety net provided with the antagonist diprenorphine. Larger doses are also in line with the manufacturer's recommendation to use heavy rather than light doses of etorphine (Carpenter and Lance 1983). The package insert for use of M99 (etorphine) in the USA states, "M99 is somewhat unique in that it is safer to give the maximum dose rather than the minimum effective dose. Under-dosing may cause hyperexcitability, hyperventilation and severe alkalosis that may lead to death. If too high a dose should be given, a very rapid reversal is obtained by the intravenous administration of M50-50 (diprenorphine)." The instruction insert goes on to recommend that "as a general rule: dose heavily, reverse quickly. This procedure minimizes the excitement stage — it may be undetectable — and avoids over exertion, exhaustion, injury and possible over-dosing by fractional repeat dosing."

Whenever considering use of etorphine to immobilize gaur, or any other animal, the human risk involved should be fully understood. Carpenter and Lance (1983) point out that etorphine is a narcotic particularly potent to humans and that the human lethal dose is just 0.03 to 0.12 mg, a mere drop. They recommend that whenever etorphine is used, Narcan (naloxone) or Nalorphine, antidotes for use in humans, and syringes should always be carried. They also recommend that etorphine be used only by designated, trained, and responsible personnel familiar with emergency treatment of an accidental administration into a human. In line with these sensible recommendations, adequate training should be provided for capture personnel prior to field use of etorphine.

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ECOLOGY OF LARGER MAMMALS OF PERIYAR WILDLIFE SANCTUARY[1]

K. K. RAMACHANDRAN, P. VIJAYAKUMARAN NAIR AND P. S. EASA[2]

(*With three plates & seven text-figures*)

Studies on the distribution, ecological requirements and resource availability to selected mammals of Periyar Wildlife Sanctuary was carried out for a period of five years from 1977 to 1982. This sanctuary is located on the crest line of the Western Ghats in Peninsular India. Forest types consist of grasslands, deciduous and evergreen forests. The study methods included recording population parameters and activities of animals sighted and collection of indirect evidences of animals from systematically laid out sample plots. The grass production from different parts of the habitat was estimated by the harvest method. A total number of 800 elephants was estimated to be present in the study area based on the quantity of dung heaps counted from the sample plots. The overall density was about one elephant per square kilometer with an ecological density as high as two or three times this in some seasons in certain parts of the reserve. The proportion of various classes of individuals in the population and their sex ratio were comparable to that of healthy elephant populations elsewhere except in the proportion of adult male elephants. Density of animals like sambar, gaur, wild boar and barking deer showed extreme variation. Frequency distribution of the number of animals in groups of sambar deer and wild boar were constructed and comparisons made with the same in other populations. Fodder and water did not appear to be a limiting factor to the animals. Based on the habits and habitat use the herbivores were classified into two groups, the first one consisting of animals like barking deer, sambar, gaur, cattle and elephant and the second group consisting of mouse deer and hare. The wild boar was not part of either of these groups. The distribution of arboreal animals like Nilgiri langur, Liontailed macaque, Bonnet macaque and Giant squirrel were examined. The availability of prey to carnivores and the competition among them were also studied.

INTRODUCTION

There have been a number of studies on the ecology of larger mammals in Asia in the last two decades. Schaller (1967), Eisenberg and Lockhart (1972), Nair *et al.* (1977), Johnsingh (1983) have brought out many details of the population dynamics, life history, prey-predator relations and habitat utilization pattern in the habitats studied. All these studies have been carried out in deciduous or scrub forest with high animal density and good visibility. The present study conducted from 1977 to 1982 in the Periyar Wildlife Sanctuary in Peninsular India examines the ecology of the larger mammals in evergreen-savannah type of forest. The results of the present study have been compared with the studies in the deciduous-scrub forests mentioned above.

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STUDY AREA

The Periyar Tiger Reserve is one of the most well known wildlife sanctuaries in Peninsular India and was a hunting preserve of the Maharajas of the erstwhile Travancore State. A masonry dam was constructed across the Mullaperiyar River near Thekkady in 1895 creating a lake of about 26 km^2 (Plate 1). Populations of significant animals like elephants, gaur, sambar, wild boar, tiger, wild dog, Nilgiri langur, liontailed macaque, Malabar giant squirrel etc. seem to have established an ecological balance with the lake and its catchment area over the years.

Location

The study area is located between 9°15′ and 9°40′ N latitude and 76°55′ and 77°25′ E longitude in the southern Western Ghats and is generally known as the Periyar Plateau. This sanctuary is situated to the west of Madurai and east of Kottayam in the Idukki District of Kerala State.

Topography

The Western Ghats is about 50 km in width at the Periyar Plateau. A considerable portion is under cash crops and forest continuity is limited to few regions. Eventhough it is called a plateau it is actually a chain of hills separated by valleys, sometimes as much as 300 m deep.

On the eastern and northern sides of the plateau along the crestline at about 2000 m elevation runs the State boundary. The elevation drops to about 200 m on the eastern side of the crestline. The western regions are also high elevation areas and slope down gradually to the coastal plains. Forested regions of Ranni and Kakki form the southern boundary of the plateau. The Periyar Plateau is mainly drained by the Periyar and Mullayar which join together near Mullakkudy. The Cumbum valley is drained by Vaigai river, the eastern slopes by Vaippar and the regions south of the Pamba Periyar Divide by river Pamba (Figs. 1 and 2). The elevation around the lake is about 800 to 1200 m, the higher regions are grass covered hills. On the southern side of the lake is the Pamba Periyar Divide, a chain of hills about 1200 m in elevation, the northern side drains to the Pamba basin. The remaining portion of the study area, the north eastern and south western regions are formed by hills of about 1500 m elevation and valleys of rivulets originating here. Tributaries of Periyar drain the western slopes of the crestline. Mullayar and Periyar flow through deep valleys amidst the hills of Periyar Plateau.

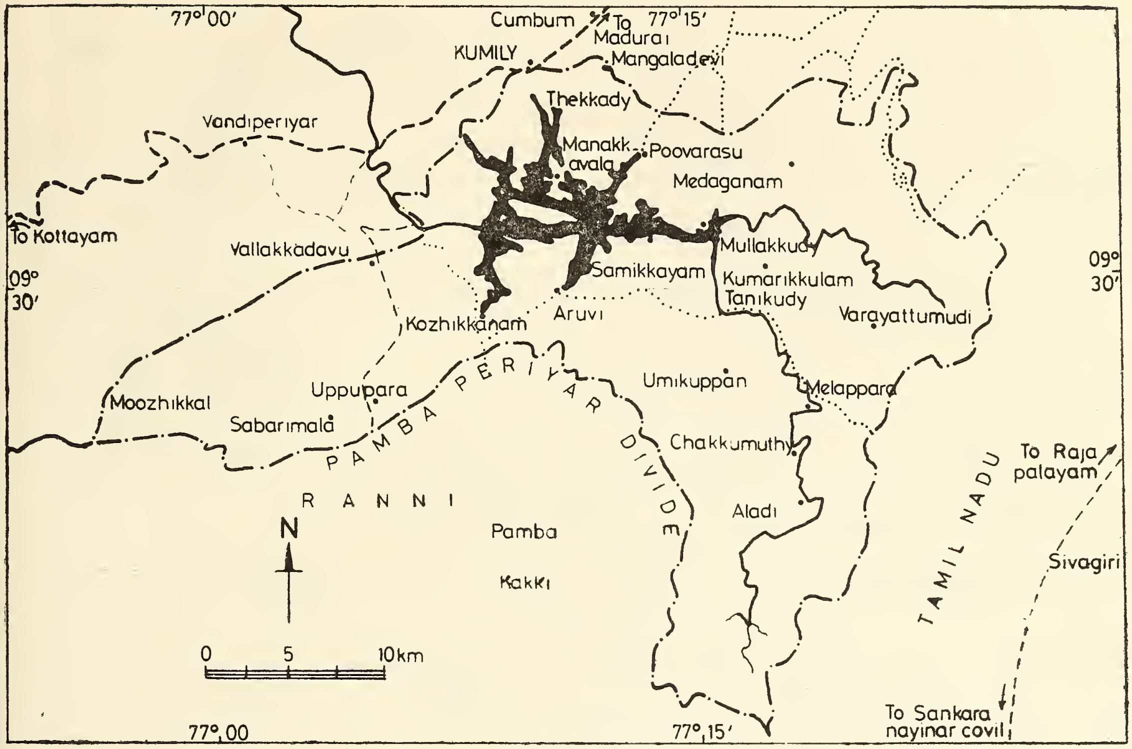
Climate

The temperature ranges from 15 to 31°C. March and April are the warmer months. Annual average rainfall is about 2000 mm with the peak in July.

History of the forests

Ward and Connor (1827) based on evidence of abandoned buildings inside the forest on Periyar Plateau show that many forest areas were under cultivation and were subsequently abandoned due to disturbance from wild animals following withdrawal of gun licence to people.

According to Bourdillon (1893) the Periyar Plateau was getting well connected with the outside world by the turn of the century; at that time Kumily was a small station and there were cardamom collection centres as far away as Melappara. He gives a description of the grasslands, large scale grazing by cattle coming from the eastern side and forest fires made by the graziers. He also described the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Medaganam
To Kottayam
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Vallakkadavu
Mullakkudy
Samikkayam
Kumarikkulam
Tanikudy
09° 30'
Kozhikkanam
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Varayattumudi
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Fig. 1. Boundaries and important place names in the sanctuary.

present submerged area of the lake as having marshy vegetation, sandy river bed and patches of forests in between hillocks.

The dam was completed by 1895. Most of the trees were not removed as it was not economical to extract them, this resulted in the present landscape of the lake filled with dry stumps (Plate 1). Mannan, Uraly, Paliyan and Arayan tribes were living inside the forest even before construction of the dam. Bourdillon (1893) reports them as living near Poovarasu, Thanikudy, Navikayam, Melappara, Ummikuppan, Vanchivayal, Pamba Valley and Moozhikkal. These people engaged in small scale cultivation but they mainly subsisted on fish, honey, tubers, etc. from the forest. The tribals were moved out of the reserve after declaring the area as a wildlife sanctuary.

In 1899 the forest around the lake was declared as a reserve forest. The Maharaja of the erstwhile Travancore State appointed Mr. C. H. Robinson in 1933 as the first game warden to constitute and maintain the sanctuary. In 1934 a sanctuary was constituted known as Nellikkampatti Game Sanctuary. In 1936 zoo bred spotted deer were introduced in one of the islands. The animals did not survive. In 1950 more areas were added to the sanctuary to constitute Periyar Wildlife Sanctuary of 777 km^2. In 1978 the area came under the Project Tiger.

There are about 20 tea and cardamom

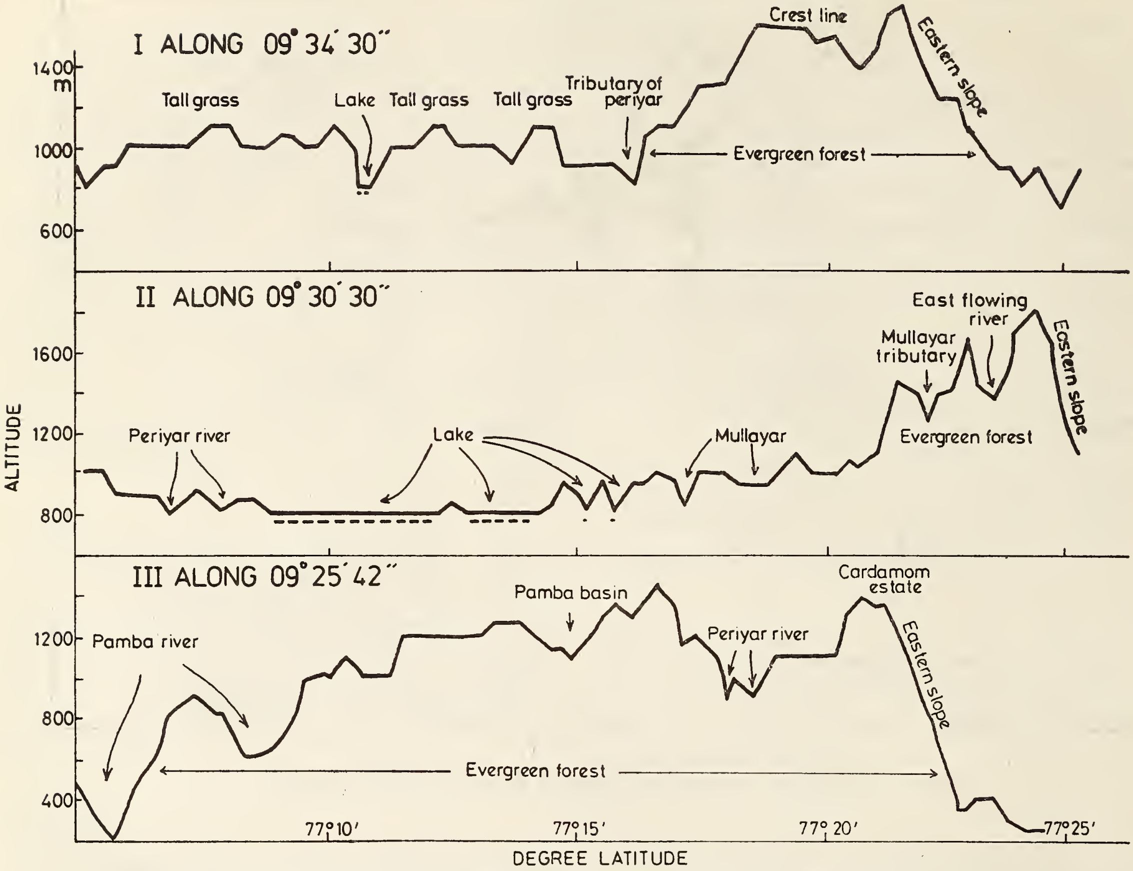


Fig. 2. Altitude profiles along three typical regions to show the position of lake, vegetation types and hills.

estates on the crestline and along the northern and eastern boundary of the sanctuary. There are four cardamom estates inside the core area of the sanctuary - Lakshmipara, Melappara, Naduthottam and Ummikuppan. The last one is maintained by tribals. Every year, thousands of pilgrims visit the Sabarimala shrine situated inside the reserve. Creation of Thekkady Development Authority, Kerala State Tourism Development Corporation's involvement in tourism, blasting of dry stumps in the boat route, tiger census by staff and students of Union Christian College, Alwaye (Varghese 1981), strengthening of the dam and increase in disturbance from eastern and northern side are some of the recent developments.

Forest types

The forest types of this region has not been properly surveyed and demarcated. According to Chandrasekharan (1973) the forest composition of the reserve is evergreen — 305 km², semi-evergreen — 275 km², moist deciduous — 98 km² and grasslands — 12 km².

In evergreen forest the trees are high, canopy is almost closed and is made predominantly of soft-wood species. Common species found are *Mesua ferrea, Elaeocarpus tuberculatus, Canarium strictum, Evodia lunu-akenda, Nephelium longana, Cullenia exarillata,* etc. Reeds are found in wet areas. Undergrowth consist of *Strobilanthus* sp., *Clerodendron* sp., etc. Various climbers (canes, *Acacia,* pepper) are also present. Plate 2 shows typical stand of evergreen forest in the reserve.

Deciduous vegetation is present only in few areas. Main trees are *Tectona grandis, Dalbergia latifolia, Lagerstroemia lanceolata, Pterocarpus marsupium, Terminalia bellerica, T. paniculata, T. chebula, Bridelia retusa, Emblica officinalis, Randia dumetorum, Grewia tiliaefolia, Bombax* sp., *Anogeissus latifolia,* etc. Undergrowth consist of *Lantana camara, Eupatorium odoratum, Zizyphus* sp., etc. *Bambusa arundinacea* has flowered around 1977 and is gradually getting established in moist areas.

There are three types of grasslands. Hill tops like Kumarikulam, Chaverkuzhy, Kathiramudi have short grass of *Heteropogon contortus* and other species (Plate 2). The elephant grass, *Cymbopogon* sp. growing to two metres occupies vast areas in the reserve. Amidst these are fire resistant trees like *Anogeissus latifolia, Bridelia retusa, Emblica officinalis, Careya arborea, Kydia calycina, Grewia tiliaefolia,* etc. These were probably wooded regions earlier and has been reduced to grassland due to frequent fire. Marshes and lake shore has succulent grasses like *Panicum repens.*

MATERIALS AND METHODS

Reconnaissance

During the reconnaissance of the study area from November 1977 to December 1978 the investigators camped in various places in the reserve and the area around each camp was surveyed intensively on foot. As the observer walked through the forest details of animals sighted, their activity, group composition and indirect evidence of animals like spoors, pugmarks and dung were noted. The details thus collected gave an indication of abundance of animals in various parts of the reserve. The findings of the reconnaissance was brought out as an interim report (Vijayan *et al.* 1979).

Animal density studies

Details of group composition such as total number of animals, their age and sex and location of sighting were used for estimating density of animals. Indirect evidences of animals collected from systematically laid out sample plots also were used for this purpose. A total number of 28 sample plots of one hectare (100 x 100 m) each were laid out on six radial lines originating from the two sampling centres. The plots were at a distance of about 2.5 km as the crow flies from each other on the radial line (Fig. 3). Thirty equidistant sub plots were marked inside these plots with numbered stakes. The entire area of one hectare was sampled for elephant dung and gaur dung. For other animals an area within three metre radius of the sub plots were sampled. The plots were cleared off all animal droppings and visited after 30 days for recording the details of droppings accumulated. Data was recorded in March-April (dry season) and October-November (wet season).

Decomposition of pellets and dung

In order to examine the interval between clearing the plots and recording data the decomposition of elephant dung and sambar pellets and hare droppings were recorded during dry and wet seasons. Droppings were marked in different types of forests in the study

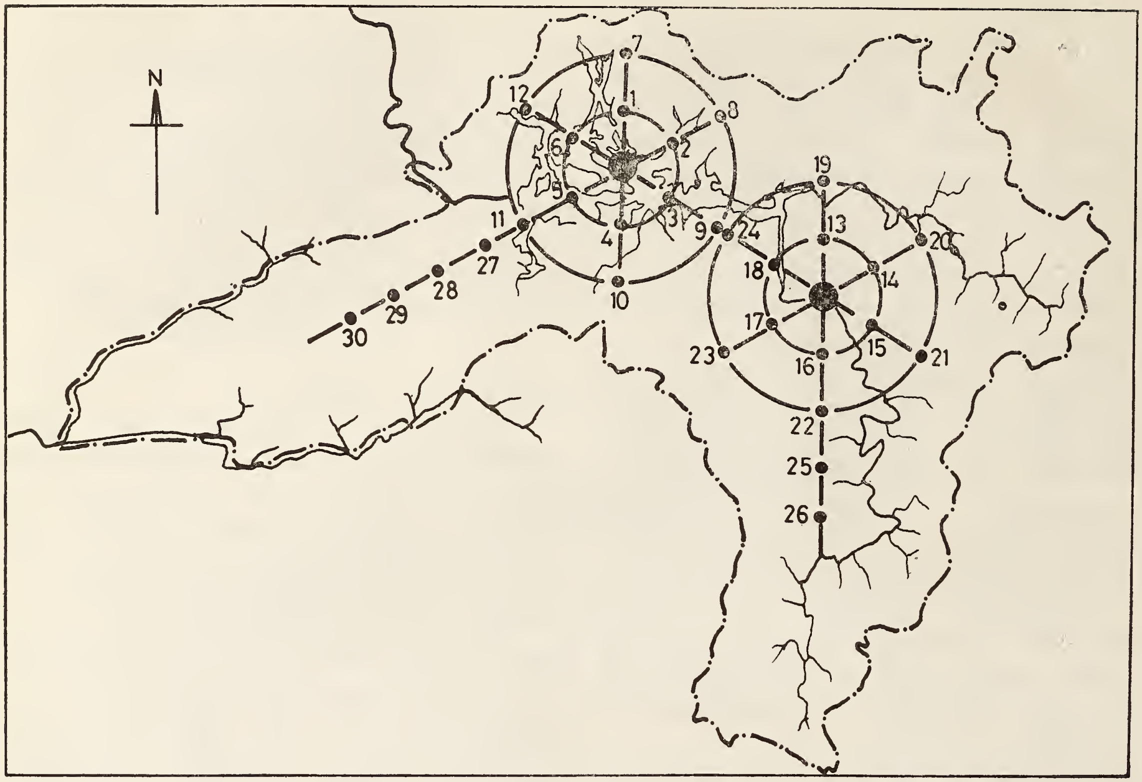


Fig. 3. Location of the sample plots.

area and degree of decomposition after one, two, five, ten and thirty days noted.

Feeding trials

Feeding trials were conducted on captive sambar deer. Grass and herbs harvested from selected plots were sorted out species-wise and fed to the animal to establish the palatable species. Equal quantities of the plants were also supplied for finding the animal's preference for different species.

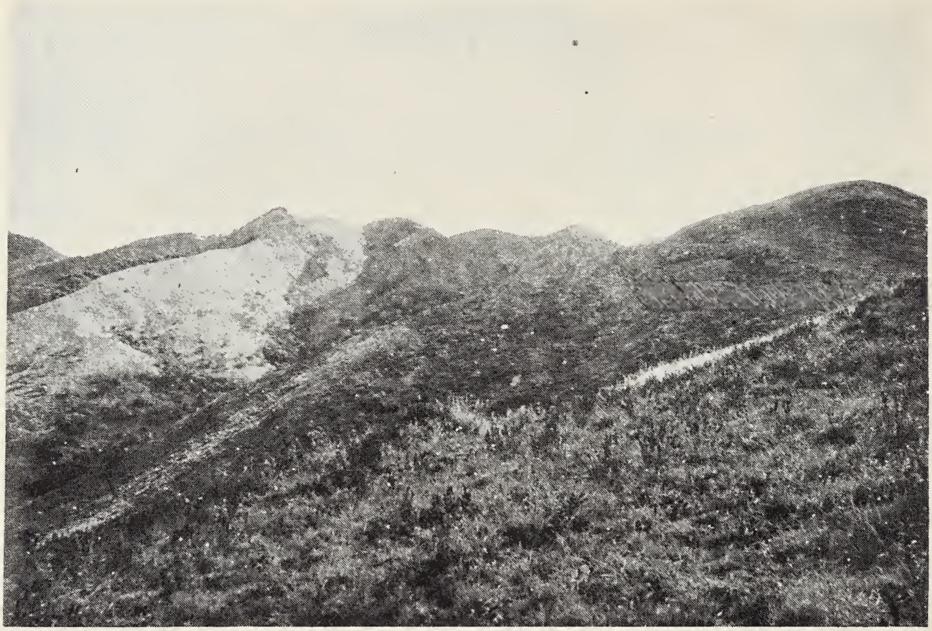
Estimation of grass production

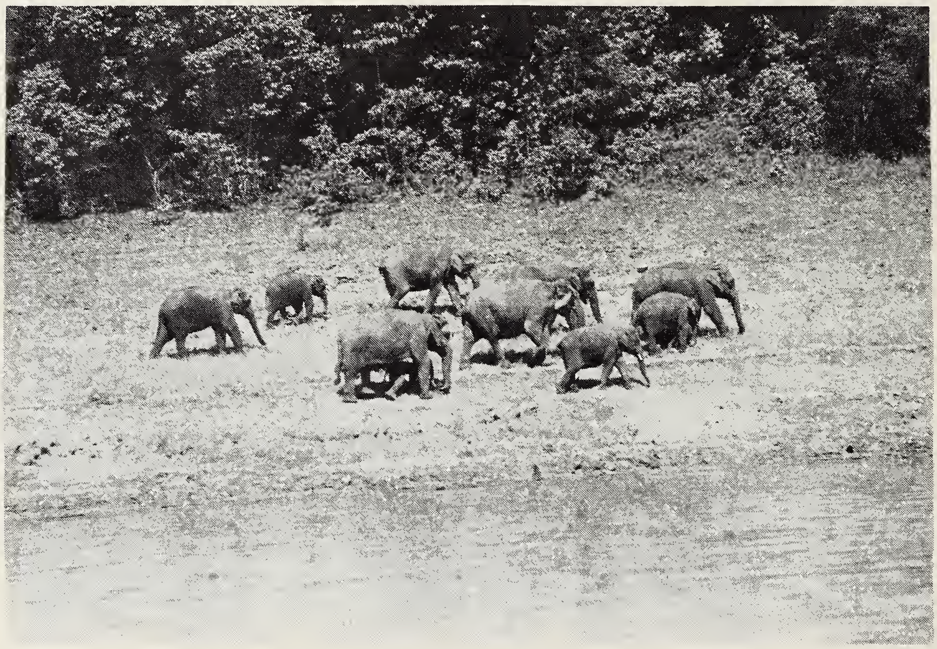
An area of 100 m² (10 × 10 m) was made inaccessible to animals by exclusion trenches (3 m depth and top width of 3 m) in three localities representing elephant grass with scattered trees amidst, tall elephant grass and marshy grassland. Grass produced both inside and outside the trenches were harvested from randomly chosen plots. The samples were oven dried and weighed species-wise.

RESULT AND DISCUSSION

The tropical warm climate, high elevation (about 1000 to 2000 m), heavy rainfall (about 2000 mm), undulating terrain, extensive grasslands, marshes, river and dense forests are highly favourable for wild animals. In general the evergreen areas contained less number of larger terrestrial animals. The evergreen areas harbour arboreal animals. Eventhough the

Above: A view of Periyar lake with dry tree stumps.
Below: A typical stand of evergreen forest in the Aladi region.





Above: Grasslands near Thanikudy region.
Below: A herd of elephant near lake shore.

densities varied animals like elephant, sambar, barking deer and gaur were present almost throughout the habitat. Hare seems to be limited to the grassland and rocky areas. Wild boar seems to have an unequal distribution, it being more abundant near marshy areas and lake shore. The status, distribution, population details and feeding ecology of various animals found in the reserve follows.

ELEPHANT

The Periyar Plateau has one of the major populations of elephants (*Elephas maximus*) in Peninsular India. Many details concerning the ecology and behaviour of the Asiatic elephants are not fully known.

Estimation of population

The population estimation is attempted based on the quantity of dung in the sample plots. Decomposition rate was found to be very high during the rainy season and hence the data during the dry season was employed for the estimation. During the month of April a total of 297 dung heaps were counted from the 22 sample plots surveyed. Benedict (1936) gives the defecation rate of 16.3 times on an average in a day. Based on more detailed studies Vancuylenberg (1977) arrived at an average defecation rate of 15 times a day. An area of 273 km^2 seems to be available as elephant habitat during the season. The number of elephants in the reserve is calculated by

$$\text{Total} = \frac{\text{Area (in ha) x dung production per ha}}{\text{Monthly defecation rate of one elephant}}$$

$$= \frac{273 \text{ x } 100 \text{ x } 297/22}{450}$$

This comes to about 800 elephants for the reserve. The overall density at Periyar was about one elephant per km^2. The ecological density in areas like Ratendan Valley, Nellikkampatti, Aruvi and Chorakotta were about three elephants per km^2 in the dry season. Eisenberg and Lockhart (1972) estimated a numerical density in Wilpattu National Park which has less resource availability at about 0.12 elephants per km^2 whereas the ecological density was as high as 1.0 to 1.2 elephants per km^2.

Herd composition and sex ratio

During the period from October 1977 to February 1982, 134 herds of elephants were observed. This includes only those herds which were fully visible. Out of this 134 herds, 15 (11.4%) were solitary individuals. Total number of individuals in all groups together was 1292.

The herd composition and sex ratio of 49 herds were accurately recorded. This shows interesting patterns when compared with those of other populations. The animals were classified into calves (less than 14 months), juveniles (14 to 40 months), subadults (40 months to 12 years in the case of females and 40 months to 15 years in the case of males) and adults (above 12 and 15 years in the case of females and males respectively). This age categorisation is similar to the one used by Eisenberg and Lockhart (1972) except for the upper age limit of subadults, for studies in Wilpattu National Park. Fig. 4 shows details of herd composition. The proportion of calves in the population was 11.8%. The proportion of juveniles was 10.2%. The adult females constituted 60% of the elephants while the adult males seen with the herds were only 1%. The subadult males and subadult females were 7.3% and 9.5% respectively. Compared to populations in other habitats the proportion of adult male elephants appears to be very low (Eisenberg and Lockhart 1972, Laws

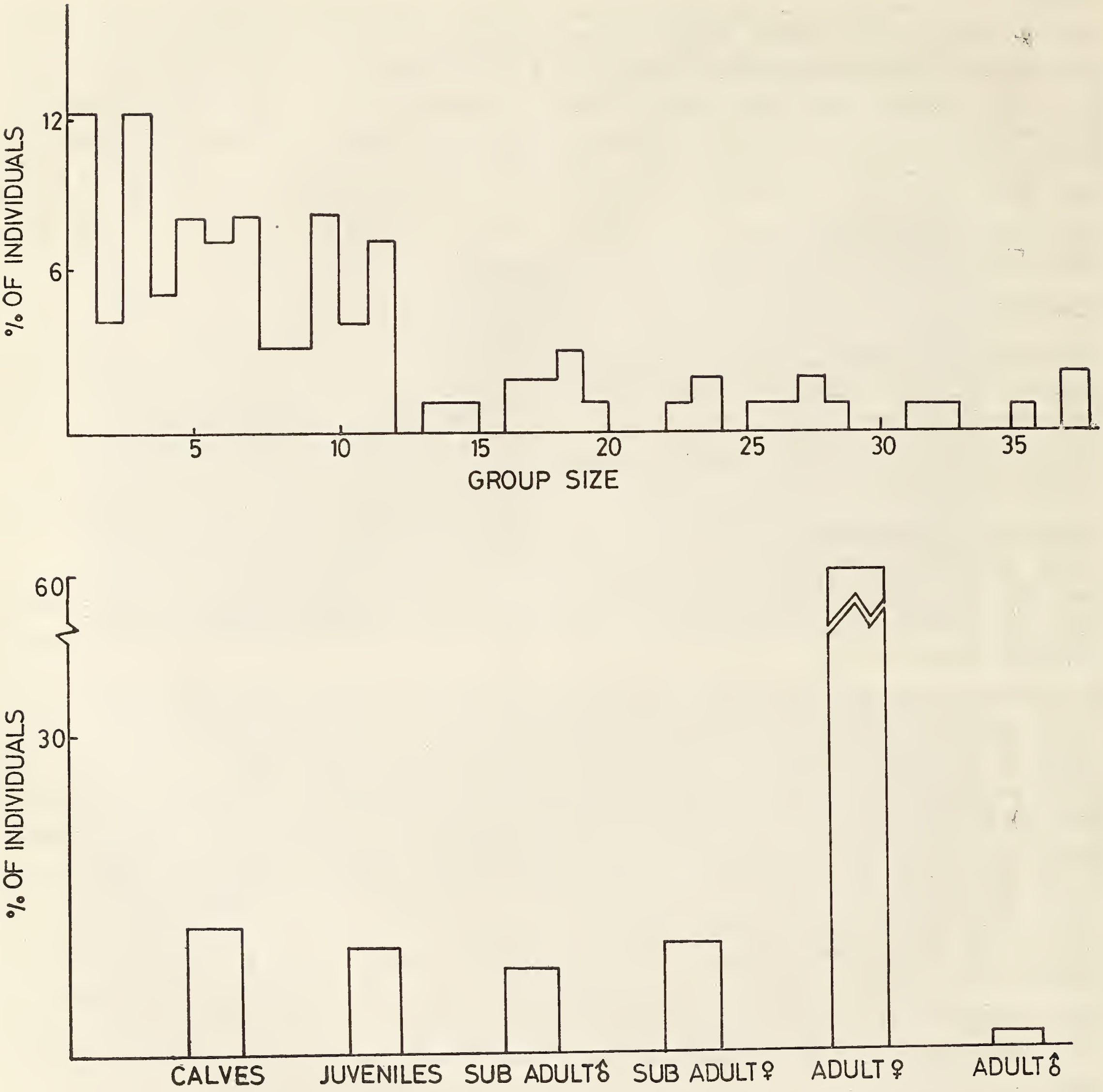


Fig. 4. Frequency distribution of herd sizes observed and the proportion of various classes of individuals in the herds.

et al. 1975, Nair *et al.* 1977). This could be due to poaching of tuskers for ivory. Fewer number of tuskers do not seem to have affected the population growth as shown by a normal number of calves. A large proportion of makhnas in the population is also unlikely. This probably means that animals classified as subadult males are sexually functional. Flower

(1943) did note that elephants may propagate their species several years before they attain their full growth. At Periyar the intensity of biotic disturbance was probably at its height during the study period. If a drastic reduction in the number of male elephants occurred during this period the result in terms of number of calves born will be apparent only after a few years, the gestation period in elephants being of this order.

The proportion of young (calves + juveniles) to adult female, subadult male to subadult female and adult male to adult female are shown in Fig. 4. The young to the adult female ratio in Periyar is similar to that of other populations. So also the sex ratio between subadult males and subadult females. There is significant difference between adult male to adult female when compared to other populations. In Wilpattu National Park in Sri Lanka for every two adult female elephant there was a male elephant (Eisenberg and Lockhart 1972), whereas this number in Bandipur and Periyar are 8.8 adult female per adult male and 57 adult female per adult male elephants respectively. When due allowance is given for the solitary nature of the male elephant and that the above figures are based on male elephants seen with herds it does not seem to be too alarming. But the shortage of adult male elephant in Periyar population is quite obvious. Plate 2 shows a herd of elephants on lake shore.

Solitary elephants

The number of solitary tuskers sighted in the study area was fewer compared to other populations as mentioned earlier. Presence of large number of makhnas in the population also do not seem to be the case. Eisenberg and Lockhart (1972) are of the opinion that makhnas are not difficult to notice in a herd because of the male elephant's habit of protruding his penis, especially while moving from one habitat to another. At Periyar solitary tuskless elephants were not encountered.

Based on sightings of tuskers from 1979 to 1982 and examination of their individual peculiarities we conclude that there are only about nine adult tuskers in the study area. Out of these only four tuskers were seen during the year 1981-82.

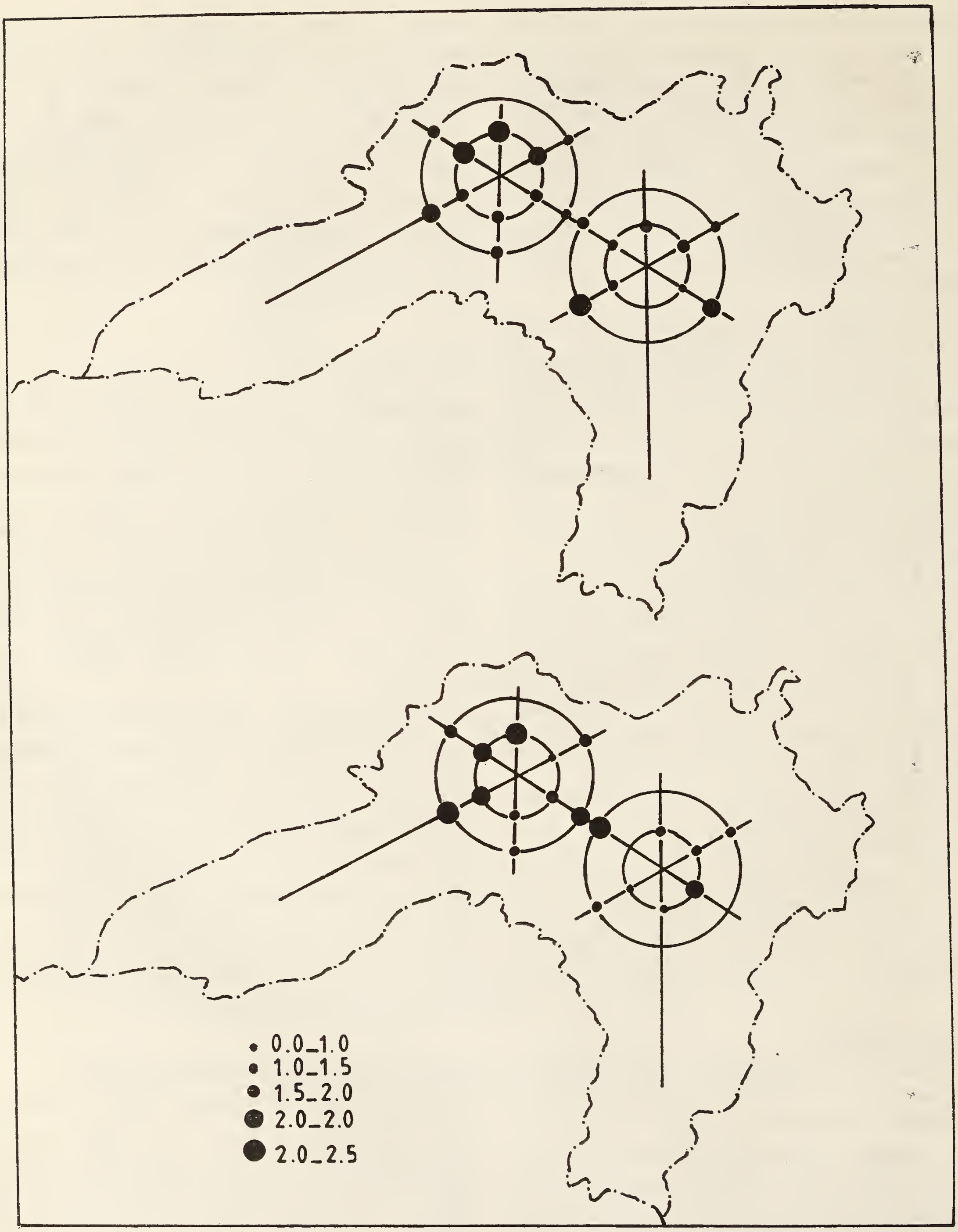
Movement pattern

In Periyar elephants are found to use the lake shore, the grassland, the deciduous forest and to a lesser degree the evergreen forest. It is not known whether elephants could move from lake areas to the evergreen forests and then to the eastern regions because of the presence of steep mountains in between. The question whether the herds observed deep inside the evergreen forests move to the rest of the area in the reserve remains unanswered.

In the Bandipur National Park elephant move away to the wet areas during summer (Nair *et al.* 1977). Elephants are seen more or less throughout the year in the study area and therefore there is no mass movement from one area to the other (Fig. 5). Our studies show that categorisation of Periyar elephants into three groups by Nair (1978) based on movement and temperament is untenable. Elephants have been sighted almost throughout the year around the lake.

Feeding habits and food requirements

Elephants feed on a large variety of plants. Their specialised trunk and thick tongue enable them to feed even on thorny plants. Grass seems to be their major food item in Periyar. Elephants feed a great deal on bamboos and reeds which are found in many


● 0.0_1.0
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● 2.0_2.5

Fig. 5. Concentration of elephants in the study area during the dry and wet seasons.

parts of the reserve. Fruits of trees like mango and jack are also eaten. An adult elephant consumes about 250 to 350 kg of green fodder (Krishnan 1975). Vancuylenberg (1977) stated that an elephant spends 17 to 19 hour a day for feeding. It consumes about 150 kg of green matter and defecates about 80 kg of dung.

GAUR

In the study area gaur has been sighted at locations like Edappalayam, Kavalappara, Chakkappara, Aruvi, Poovarasu, Panamkala oda, Ottamaram, Kattumadu mottai, Kumarikulam, Varayattumudi, Chaverkuzhi, etc. in different types of vegetation. The gaur is a widely ranging animal, sometimes migrating to adjacent areas when food becomes scarce (Krishnan 1976, Johnsingh 1980). It is not known whether there is any such movement to adjacent areas by these animals in Periyar or how far and how long they stay in a particular locality.

The total number of gaur and their sex ratio in the sanctuary could not be estimated accurately due to the very scanty population which is slowly getting established after the rinderpest outbreak in 1974. Rinderpest seems to play an important role in regulation of gaur populations. The population builds up at a rapid rate and the animals become numerous in large herds readily seen in sanctuaries. An outbreak of a contagious disease like rinderpest almost wipes out the population and the whole process repeats. The periodicity of rinderpest occurrence is not known.

Food requirements

Gaur is described as both a grazer and a browser preferring green grass when available but otherwise consuming coarse dry grass and large variety of forbes, leaves and fruits (Schaller 1967, Krishnan 1975) like *Hibiscus lampus, Grewia aspera, Grewia hirsuta, Desmodium pulchellum, Emblica* sp., *Cordia myxa, Zizyphus trinervia, Zizyphus xylopyrus, Smilax zeylanica, Gmelina arborea, Terminalia bellerica* and *Bambusa arundinacea* which are present in the reserve. The gaur in captivity is reported to consume about 20 kg of green fodder a day. In the wild it visits water bodies at least once during hot days.

SAMBAR

Two factors, dense cover and water influence the distribution and abundance of sambar (Johnsingh 1980). In the study area there were small groups of animals in every hillock or valley. They are not very conspicuous and their non-gregarious nature and dispersed distribution tends towards an underestimation of their number. The largest group seen consisted of ten individuals (seven does and three fawns).

Sambar is an important prey species in the sanctuary. Wild dogs can often be seen chasing them to water and killing them in water. For other carnivores such as panther and tiger also they form an important prey species.

Food requirement

Sambar deer like the gaur is a browser and grazer. According to Schaller (1967) young grass constitute their major forage during the rainy season. Browsing is resorted to when grass is scarce. In Periyar small groups of sambar can be seen grazing on the lakeshore and grassland. Their nipping the tender leaves of *Panicum repens* in marshy areas is particularly noticeable. Feeding trials on a captive sambar deer showed high preference for grass. In captivity sambar deer are given 2.6 kg of green leaves and 3.0 kg of grass daily. Fruits of *Emblica officinalis, Zizyphus jujuba, Randia dumetorum, Terminalia belle-*

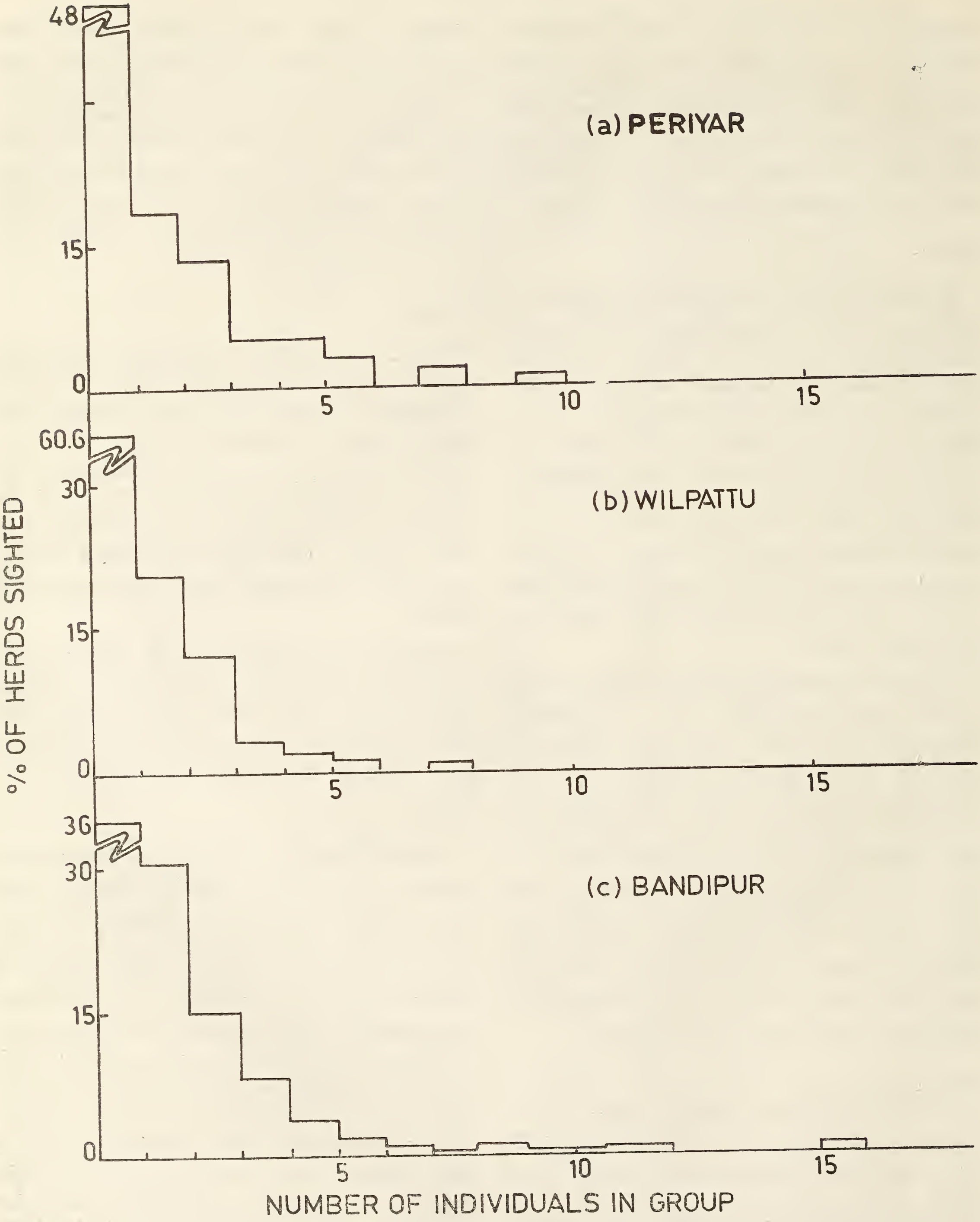
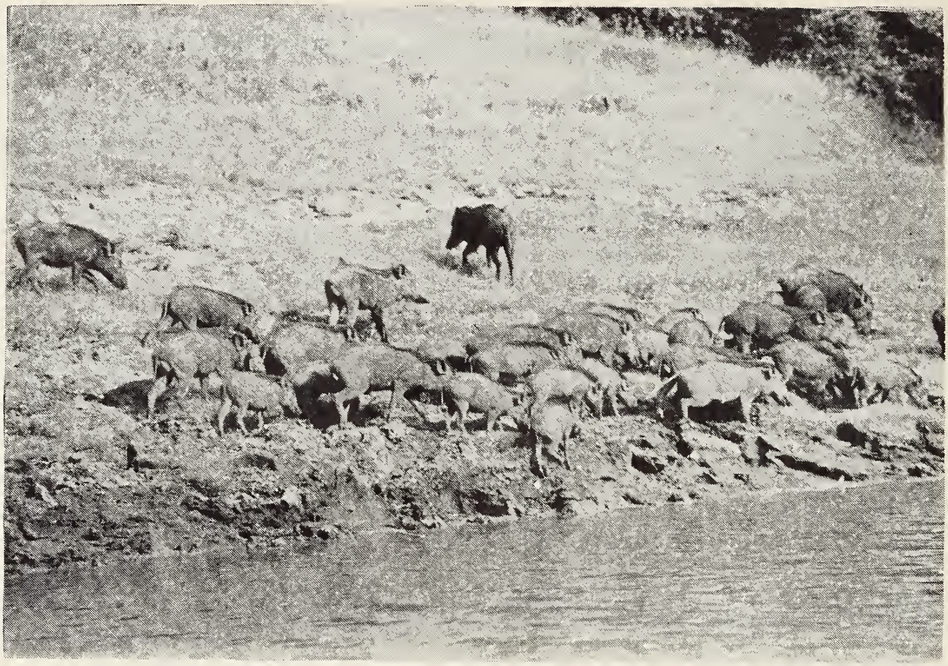
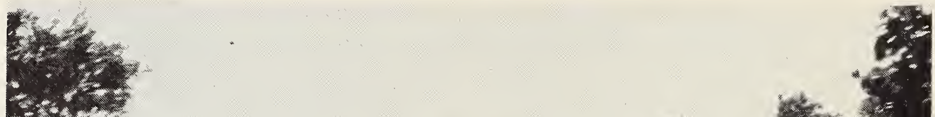


Fig. 6. Distributed of group sizes of sambar deer sighted.





Above: A large sounders of wild boar near the lake shore.
Below: Nilgiri langur jumping from one tree to another.

rica, T. chebula also are eaten in large quantity when available. The thickets of *Lantana camara* and *Bambusa arundinacea* provide them shelter and fodder. They visit waterholes almost everyday, sometimes at night.

Population density

The sambar deer seems to be very unevenly distributed in the reserve. Some areas have very high concentration of these animals. Four study plots contained as much as about 75% of the pellets collected.

Herd composition and sex ratio

The frequency distribution of number of animals in sambar groups seen is shown in Fig. 6. Sambar populations in other areas examined show remarkable similarity with that of Periyar with the solitary individuals occupying 30-50% of the total. The group size rarely exceeds eight individuals. Johnsingh (1980) found a density of 4.2 sambar/km² in wet season and 2.25 sambar/km² in the dry season in his focal study area at Bandipur. The density of sambar in the Kanha National Park was estimated ot be 1.6 to 2.3 animal/km² (Schaller 1967). The density of sambar in the Wilpattu National Park was estimated at 1.17 animals/km² (Eisenberg and Lockhart 1972).

Sex and age distribution

Attempts were not made for determining age of sambar deer during visual observations. The sex could be identified for larger individuals. Out of 104 individuals accurately sexed 33.65% individuals were males, giving a male to female ratio of 1:3. All age categories seem to be represented in the pellets collected from the sample plots. Sambar stags were seen in velvet during the months of March, May, June, August and December. This rules out a particular season for shedding antler.

WILD BOAR

The Wild Boar (*Sus scrofa*), one of the most widely distributed non ruminant ungulates in peninsular India is also one of the least studied animals.

The animals are seen in sounders ranging from a few to about sixty individuals. In some seasons large sounders of 80 or more individuals can be seen (Plate 3). The significance of such aggregations, seen only on few occasions is not known. Lone animals can also be frequently seen. The sightings of pigs in the reserve show that they are seen mostly around the lake, and sounders ranging from six to eleven individuals were most well represented. In the Wilpattu National Park (Eisenberg and Lockhart 1972) wild boars have the highest frequency of four individuals; after the single individuals. Sounders consisting of four to fifteen individuals were most common, there being fewer groups near the upper margin (Fig. 7). The high incidence of solitary individuals, mostly males, suggest the possible existence of elaborate social structure.

Opinions vary about the ranging pattern of the Wild boar. Eisenberg and Lockhart (1972) found them to be migratory in the Wilpattu National Park while Johnsingh (1980) considers them to have a fixed home range in Bandipur. In Periyar there do not seem to be any migration as indicated by sightings almost throughout the year. Unlike many sanctuaries they can be seen more readily in Periyar, almost throughout the day especially in the tourism zone.

Our observations indicate that the members of a particular sounder are fixed and also that the adult males are solitary, probably joining the sounders only for mating. A case of wild boar feeding on carcass of their own species was also reported. At the reserve they

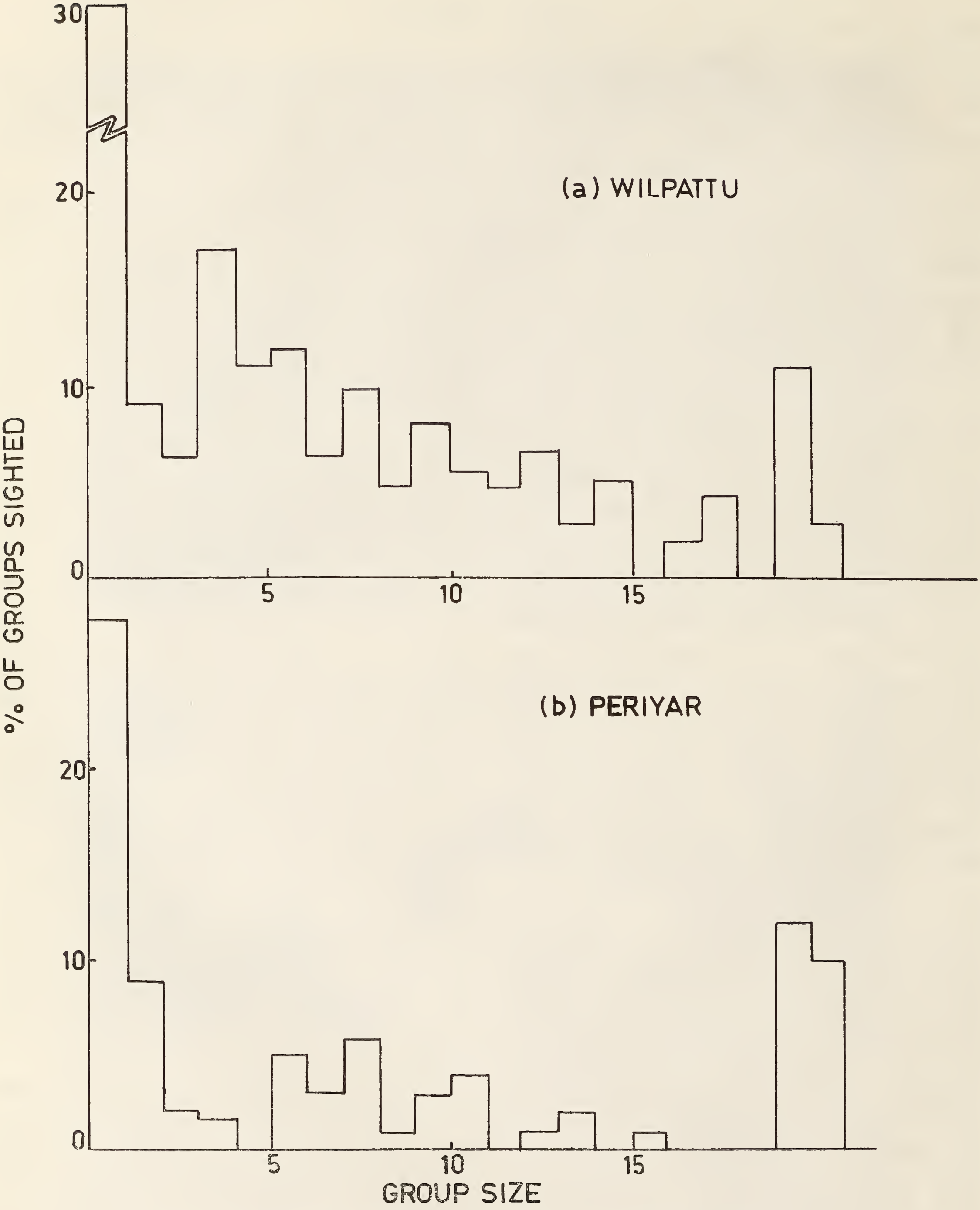


Fig. 7. Distribution of groups of wild boar in Wilpattu and Periyar.

can be approached close on foot and they move away only at very close distance. When approached very close on foot they make threat displays. Flocks of jungle mynas can be seen accompanying wild boar and other grazers for catching the flushed insects.

Wild Boar mostly lives in open habitat, grass or scanty bush jungle and prefers thick forest least. They are omnivorous living on a variety of roots, tubers, insects and carrion. The tubers notably of *Panicum repens* in marshy areas seem to be an important food item in Periyar. They were seen feeding on tadpoles of *Rana curtipes* which appear in large quantities in some seasons in the lake. There was an instance of a wild boar feeding on a dead fish.

SMALLER MAMMALS

The barking deer, mouse deer and the black-naped hare are included in this section. These are mostly very shy animals and occupy a habitat at the edge of the forest.

The barking deer (*Muntiacus muntjak*) is described as a solitary animal which hides the young ones in thickets till they are mature (Eisenberg and Lockhart 1972). A captive male barking deer kept by us was fatally attacked by a wild male. This probably shows that the males are territorial and actively keep off other males. Nature of the male female bond is not known. Barking deer was recorded in areas like Chevlod, Manakkavala, Ottamaram and Thekkady. Because of difficulty in distinguishing the pellet from that of Sambar and mouse deer detailed computations were not attempted.

Nilgiri Tahr (*Hemitragus hylocrius*) the endangered ungulate is no more seen in the reserve even though they have been reported to be present on the tall steep hill tops.

Mouse deer (*Tragulus meminna*) is a small solitary deer, nocturnal in habit with a colour pattern suitable for concealment (Eisenberg and Lockhart 1972). We have recorded a case of wild dogs killing a pregnant mouse deer in the month of April. Eisenberg and Lockhart (1972) suspect a consistent home range and the mouse deer having social interactions at least in the breeding season. There was difficulty in distinguishing pellets of mouse deer from that of young of other deer and hence detailed computations of age categorising were not attempted. The frequency distribution of pellet size was symmetrical. Mouse deer droppings were observed mostly in Chevalod and Ottamaram plots.

The blacknaped hare (*Lepus nigricollis*) also is not very active during the day time, it hides in grass during day. They seem to prefer forest edges. Their droppings are very common in rocky areas.

AVAILABILITY OF FODDER TO HERBIVORES

Grass is abundant in the grassland on hill tops, savannah areas, lakeshore and marshes. Of these the grass in regions other than lake shore and marshes is mainly *Cymbopogon* sp. which is palatable only in young stages and is burned in the summer resulting in scarcity of grass. The evergreen forest also contain grass where the canopy is not closed. This grass is available almost throughout the year.

Attempts were made to estimate the grass production in grassland, marshy area and savannah areas. The grass production is quite high in the grassland areas as shown by harvesting experiments described below. The grass production at the end of the growth season is about 700 tonnes/km^2. About 20% of the grass produced is consumed by herbivores. This means that animals depend upon other plants and grass in the deciduous and evergreen areas a great deal. Of the different sites, Edappalayam had the maximum grass production followed by Manakkavala and Thanikudy. The three sites had different grass species, Edapalayam and Thanikudy predominently elephant grass and Manakkavala predominently *Panicum* sp. characteristic of marshy regions near the lake.

At Edapalayam, at the beginning of the growth season, no direct comparison was possible as the regions outside the protected part burned. Total grass and herbaceous vegetation had a dry weight of 196.31 gm/m^2 inside trench and 205.22 gm/m^2 outside. In the ungrazed regions *Cymbopogon* sp. accounted for 98.69% of the total weight. But in grazed regions only for 85.82% of the total. Species *Cymbopogon* and *Desmodium* seem to be heavily grazed whereas *Desmostachya bipinnata, Cyperus* sp., *Eupatorium odoratum* etc. were more in grazed areas. Total grass production at Manakkavala in ungrazed accounted to 711.8 gm/m^2 and 592.72 gm/m^2 in grazed areas. On the whole the species diversity seem to be less in the marsh compared to other areas, *Panicum repens* accounted for 93.89% of the total dry weight in grazed areas and 95.46% in the ungrazed areas. This is an important grass because elephants depends on this in the dry season to a great extent; the wild boar feed on its rhizomes, the sambar eats its tender shoot tips.

Bamboo flowered around 1977 and was getting established again only during the study period. Coming to trees there are very few trees the elephants directly fed upon. Bark of *Grewia tiliaefolia* was eaten. The number of these trees in the forest seem to be very few. The deciduous areas have *Lagerstroemia lanceolata, Terminalia chebula, Bridelia retusa, Emblica officinalis, Randia dumetorum, Careya arborea, Dillenia pentagyna,* etc. Elephants hardly feed on any of these. Fruits of most of the other trees are eaten by sambar, barking deer, etc. Enumeration of these trees or their phenology was not done. Regarding the numerous evergreen trees no particular tree seems to be extensively fed by elephants. Concerning the feeding of arboreal animals like giant squirrel, flying squirrel, bonnet macaque, liontailed macaque and nilgiri langur, their feeding habits were not investigated in detail.

Competition among herbivores

The herbivores considered are elephant, gaur, sambar, cattle, wild boar, barking deer, mouse deer and hare. Ten biological factors such as degree of tree use, degree of usage of shrubs, browsing, grazing, dependance on underground tubers, need for water, diurnal/nocturnal nature, preference for open habitat and sun tolerance were considered. Elephants feed on trees like *Grewia* and *Ficus* sp. Sambar deer and barking deer feed on fallen fruits. In using the shrubs also elephants top the list with its ability to break the stem and to feed from considerable height. Most of the animals considered are capable of both grazing and browsing. Only wild boar and elephant are able to dig or pull out underground stems and tubers. Need for water is more or less similar among the animals, wallowing animals like the wild boar, sambar and elephants needing it more than small deer like barking deer and mouse deer. Most of the animals were active during day time, the mouse deer and barking deer are more active during dawn and dusk. Elephants, hare and mouse deer have been found to be active during considerable part of the night also. Sun tolerance was rated maximum for cattle and least for the solitary deer. Hare was considered as an animal of the open habitat. Other animals preferred mostly a habitat with both open areas and cover. The highest density of sambar deer was recorded in Kadukkapara area with extensive *Lantana* thickets. The *Lantana* shrubs were very heavily browsed in this area. This is particularly notable because *Lantana* is usually described as an unpalatable weed.

A similarity matrix of similarity in habits and habitat use of the above herbivores was prepared from subjective values assigned to each of the parameters. Clustering by the hierarchical method (Cody 1974) show animals like barking deer, sambar, gaur, cattle and elephant forming one group and animals like mouse deer and hare forming another group. The Wild boar is not in either group and stands out alone having the least overlap with the rest of the animals.

ARBOREAL MAMMALS

The Malabar giant squirrel, flying squirrel, bonnet macaque, Nilgiri langur and the liontailed macaque are the major arboreal mammals.

Malabar Giant Squirrel

This squirrel (*Ratufa indica*) is found in deciduous to evergreen vegetation, and builds large globular nests of twigs and leaves on smaller branches of tall trees. Giant squirrel is seen almost throughout the sanctuary. They feed on a large variety of fruits, barks, leaves and seeds. Their extensive feeding on teak seeds is particularly remarkable. They have been observed to feed on jackfruit, *Terminalia paniculata* (fruits), *Bombax malabarica* (seeds), *Machilus macaranga* (flowers), *Pterocarpus marsupium* (bark), etc.

Flying squirrel

Petinomys fuscocapillus, the small Travancore flying squirrel has been observed in the Thekkady region. This animal is mainly nocturnal, very active during dusk.

Liontailed macaque

This endemic endangered arboreal macaque, *Macaca silenus* is limited to the evergreen forests of western ghats — Nagercoil district to North Kanara (8°-15°N and 75°-80°E) (Karr 1973, Green and Minkowski 1977, Kurup 1978, Johnson 1980). In Periyar, they were recorded in Melappara cardamom estate, Elatheri, Koyilmala, Ponvarai, Pachakanam, Aladi, near the eastern border and Pachiar estate. A lone monkey was seen near Sabarimala temple. A troop of seven individuals were sighted in Poonkavanam area. In Pachakanam area as described by Kurup (1978) their number is on the decline due to human activity. Near Melappara cardamom estate a troop of 32 liontailed macaques were sighted.

Green and Minkowski (1977) observed that the liontailed macaques feed on *Cullenia exarillata* and *Artocarpus heterophyllus* almost throughout the year. Preference for other species vary between different months of the year. Other important species for the animal are *Tetrastigma sulcatum, Litsea wightiana, Loranthus elasticus,* etc.

Periyar has one of the most extensive evergreen forests harbouring this monkey. The exact number, troops and general distribution in this reserve has not been thoroughly investigated so far (Green and Minkowiski 1977, Kurup 1975) due to the extreme difficulty in approaching this area and rugged nature of the terrain.

Bonnet macaque

Those found in the natural forest were very shy and smaller in size compared to the ones found near habitation.

Bonnet macaques have been found in Melappara, Elatheri, Ummikuppan, Anchuruli, Tanikudy, Vaikkappadappu, Koyilmala, Pachaiyar estate, etc. These monkeys live in highly social groups. The largest troop found consisted about 40 individuals.

Nilgiri langur

The Nilgiri langur, *Presbytis johnii* is commonly found almost all over the reserve (Plate 3). They have been reported to feed on plants like *Pterocarpus marsupium, Grewia tiliaefolia, Dalbergia latifolia, Artocarpus hirsuta,* etc. (Roonwal and Mohnot 1977). Group size varies from three to 35 individuals and the home range is proportional to the group size ranging from a few hectares to few km^2.

CARNIVORES

Sloth bears were recorded from places like Manakkavala, Medaganam, Mullathode, Ottamaram, Mulakupara, Chaverkuzhy, Vaikkapadappu, Chorakotta, Koyilmala, Pulikkayam, Kozhikanam and Edappalayam. The sloth bear seems to prefer available paths in the forest as indicated by droppings and foot prints. They consume fruits of wild mango, *Zizyphus jujuba, Syzigium cumini, Cassia fistula, Cordia myxa,* etc. when available. A charred body of a sloth bear was observed in March 1978 at Chamikayam medu in the burnt grassland.

Otter

The Otter (*Lutra* sp.) is present in the lake and upstream of Periyar in good numbers. They are seen in groups ranging from a few individuals to about 15 animals. They feed mainly on fish in the lake. A territorial habit is suspected as groups are repeatedly seen near particular areas.

Tiger

The Periyar Wildlife sanctuary has been declared as a Project Tiger area in 1978. No details are available regarding the previous number of tigers in the reserve. Varghese (1975) estimated a total of 30 tigers (11 males, 5 females, 8 subadult males, 3 subadult females and 3 cubs) in the reserve. By 1981 the number of tigers had increased to 38 with 16 adult males, 10 adult females, 8 subadults and 4 cubs (Varghese 1981). These studies are based on analysis of pugmarks. During the reconnaissance period about 25 to 30 tigers were estimated based on spatial distribution of indirect evidences.

Tigers were sighted at Edappalayam, near boat landing, Manakkavala and Thanikudy. Pug marks were seen in areas like Ummikuppan, Melappara, Thanikudy, Manakkavala, Panankala Oda, Poovarasu, etc. A total of four kills were examined, out of these three were domestic cattle and fourth a sambar stag. In all cases the tiger shifted the carcass about 200 metres each day.

Leopard

Only very limited details could be collected on Leopard, *Panthera pardus* from the study area. It is possible that many of the foot prints were mistaken for that of the tiger due to difficulty in recognising the pugmarks of tiger and leopard.

Wild dog

In Periyar the pack size ranged from 2 to 14. At Kanha the pack size was 2 to 12 animals (Schaller 1967). Johnsingh (1980) is of the opinion that pack size will be small in areas where food is scarce. Wild dogs were sighted in areas like Manakkavala, Edappalayam, Thekkady boat landing, Thanikudy, Melappara, Paravalavu, Medaganam, Cheriyakanam, Nellikkampatti, Anchuruli, etc. The main prey of wild dog in the reserve seem to be sambar deer. Often the wild dogs were seen chasing the sambar to water and biting them to death, swimming around it. One wild dog was found dead, presumably from injuries sustained during hunting. Near the inhabited areas in the reserve people used to take away deer killed by the wild dog. Johnsingh (1980) is of the opinion that in these cases where the kills have been stolen wild dogs attempt one more kill on the same day.

Availability of prey and competition among carnivores

At Periyar the sambar deer constitute a major prey species for the wild dog, leopard and tiger. Spotted deer is not present in Periyar. The wild boar form the second prey species. We have recorded cases of wild dog hunting barking deer and mouse deer. Porcupine quills in some tiger droppings indicate tiger preying upon porcupine also.

CONCLUSION

As a habitat for herbivores, Periyar Wildlife Sanctuary contains sufficient fodder, water and diversity of forest. The overall density in the case of elephants is about one animal per km^2. Whereas the ecological density is as high as three elephants per km^2 in some areas in the dry season. The dense evergreen forests are found to be less suitable for larger mammals like elephants, gaur and sambar. Certain ecologically rich portions of the habitat consisting of lake shore, marshes and bushy thickets contain high density of deer species. There is a high concentration of wild boar near the lake shore due to abundant food availability and protection. High rainfall, lack of medium sized prey animal and uneven distribution of the prey animals seem to keep the density of carnivores in Periyar to a lower level.

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SOME ECOLOGICAL ASPECTS OF MANGROVE FOREST OF ANDAMAN ISLANDS[1]

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S. M. PATHAK[2]

(*With two text-figures*)

INTRODUCTION

Mangroves are defined as characteristic littoral plant formations of tropical and subtropical protected coastlines. No other plant community in the world has perhaps, attracted more scientific attention than mangroves, primarily on account of their growing on a highly stressed habitat due to high amount of dissolved salts in the substratum and the water which periodically covers the root system during tides and the very poor amount of aeration available. Also the presence of various types of aerial roots primarily for aeration and viviparous seedlings hanging on most of the trees are characteristic features. In India mangroves are found in very limited areas — Gangetic delta, mouths of Mahanadi, Godavari and Krishna, Cauvery delta, Bombay region, Saurashtra and Kutch coast and Andaman and Nicobar Islands. Nearly 85% of the Indian mangals are confined to West Bengal and to the Islands of the Andaman and Nicobar groups. A study of mangrove vegetation of Andaman and Nicobar Islands was undertaken to know the ecological status, composition, stratification and zonational pattern.

Andaman group consists of 204 islands (Parkinson 1923) but according to the latest information it includes 291 islands, forming a chain lying in a north-south direction. The land area of the whole group is approximately 6,400 sq. km.

Climate: The year may be divided into dry season and rainy season, and there is a little fluctuation in temperature with a brief cold season during the months of December and January. Dry season occurs from the months of January to April during which little, if any rain falls. In the months of February and March the weather is often sultry, and very little wind blows. The rainy season occupies the rest of the year, and during this period, varying degrees of rain occurs. The rainfall ranges from 279.4 to 433.5 cm per year, and varies in different parts of the islands.

Soil: The soil of Andaman archipelago is usually soft, deep sandy loam, varying from a fine texture on the alluvial flats to gravel strewn soil. Under mangrove formations there is saline low-lying land, which is usually of alluvial nature. This is inundated at regular intervals by the rise and fall of tides.

Vegetation: The five main types of vegetation in Andaman group have been recognised by Parkinson (1923) as

a. Mangrove forest
b. Beach forest
c. Evergreen forest
d. Semi-evergreen forest
e. Alluvial forest.

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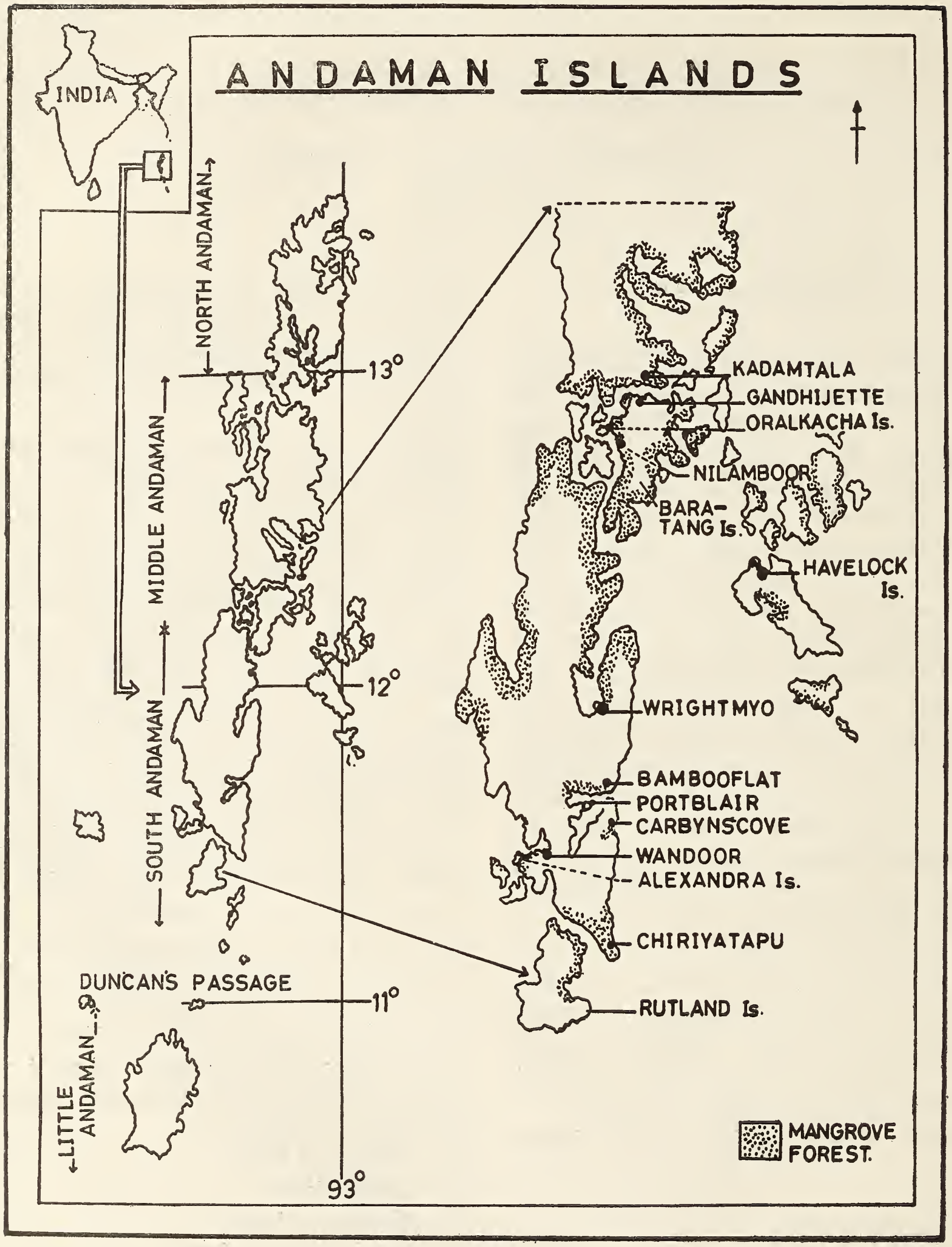
ANDAMAN ISLANDS
INDIA
NORTH ANDAMAN
MIDDLE ANDAMAN
SOUTH ANDAMAN
LITTLE ANDAMAN
DUNCAN'S PASSAGE
13°
12°
11°
93°
KADAMTALA
GANDHIJETTE
ORALKACHA Is.
NILAMBOOR
BARA-TANG Is.
HAVELOCK Is.
WRIGHTMYO
BAMBOOFLAT
PORTBLAIR
CARBYNSCOVE
WANDOOR
ALEXANDRA Is.
CHIRIYATAPU
RUTLAND Is.
MANGROVE FOREST

Fig. 1. Sketch map of the Andaman Islands, showing their position (in inset) mangrove forest (light shading) and localities mentioned in text.

According to Chengappa (1944) the area under mangrove forest is nearly 44.330 hectares, total area of the Andaman mangrove is estimated at about 1,00,000 ha (Blasco 1977).

Study sites: On the basis of extensive survey of these islands following sites have been selected for details study due to differences in substratum, topography, habitat, etc. (fig. 1).

Site-1 Alexandra Island: Situated nearly 36 km from Port Blair. Here the substratum is sandy and mangal formation is dense and mostly species of *Rhizophora* dominate.

Site-2 Wandoor: Situated at about 36 km from Port Blair very near to site-1. The substratum is muddy and sandy and vegetation is almost similar to that of the 1st site with dense population of animals, e.g. mudskippers and snails.

Site-3 Carbynscove: Located towards the east coast of South Andaman, 15 km from Port Blair, the substratum is clayey and muddy, with lot of human disturbance.

Site-4 Chiriya-tapu: On the south coast of South Andaman, 42 km from Port Blair. There is open formation of rocky and stony shore. Here mangrove formations are found on rocky substratum.

Site-5 Bambooflat: This site is along an inlet stream and is muddy with marked mangal formation. Some of the area is under acute human disturbance.

Site-6 Wrightmyo: The site is along creeks and is marshy and muddy with dense mangal formation.

Site-7 Oralkatcha: Situated at a distance of 35 km from Port Blair. This is an Island having a sea creek and inlet streams. Here the best developed mangrove was noticed.

Site-8 Nilamboor: An island having a sea creek and inlet streams. Here also very goodgrowth of mangrove was noticed. The soil is muddy and sandy and vegetation is almost similar to previous one.

Site-9 Gandhi jetty: This site is situated along long creeks and mangrove formations are found on large flat areas.

Site-10 Kandamtala: Situated in the Middle Andamans at distance of 60 km from Port Blair. Mangrove formations are found on large flat areas along the creek.

METHODOLOGY

Phytosociological studies were made during 1983 to 1984 along a series of transects across the tidal flats. Transects were selected to cover a wide range of mangal types. For the determination of composition and structure of mangrove forest at various sites, presence and absence of each plant species in each site were noted and finally percentage species composition was calculated following Philips (1954).

Sorensen index of similarity was used for the quantification of communities which was calculated on the basis of Sorensen (1948). Complexity index was calculated using the method given by Holdridge (1967). Soil samples at different sites were collected from 15 cm depth and all the soil analysis was done by following Piper (1942) and Jackson (1958).

RESULTS AND DISCUSSION

Floristic composition: The tidal zones of tropical seas are frequently lined with great mangroves. The outstanding features of these plants are adoptation to growing in sea water and establishing themselves in estuaries, creeks and lagoon areas. The coast line of the islands

TABLE 1

MANGROVE SPECIES RECORDED DURING THE SURVEY OF VARIOUS SITES

S.N.	Family		Species
1.	ACANTHACEAE	1.	*Acanthus ilicifolius* L.
		2.	*A. ebracteatus* Vahl
2.	AVICENNIACEAE	3.	*Avicennia marina* (Forsk.) Vierh.
		4.	*A. officinalis* Blume.
3.	MYRSINACEAE	5.	*Aegiceras corniculatum* (L.) Blanco
4.	RHIZOPHORACEAE	6.	*Bruguiera gymnorhiza* (L.) Lam.
		7.	*B. parviflora* (Roxb.) Wight
		8.	*B. cylindrica* (L.) Blume
		9.	*B. sexangula* (Lour.) Poir.
		10.	*Ceriops tagal* (Perr.) C. B. Rob.
		11.	*Rhizophora apiculata* Blume
		12.	*R. mucronata* Lamk.
		13.	*R. stylosa* Griff.
		14.	*R. lamarckii* Montr.
5.	EUPHORBIACEAE	15.	*Excoecaria agallocha* L.
6.	COMBRETACEAE	16.	*Lumnitzera littorea* (Jack.) Voigt
		17.	*L. racemosa* Willd.
7.	PALMAE (NYPACEAE)	18.	*Nypa fruticans* Wurmb.
		19.	*Phoenix paludosa* Roxb.
8.	RUBIACEAE	20.	*Scyphiphora hydrophyllacea* Gaertn. f.
9.	SONNERATIACEAE	21.	*Sonneratia alba* J. E. Smith
		22.	*S. apetala* Buch.-Ham.
10.	MELIACEAE	23.	*Xylocarpus granatum* Koen.
		24.	*X. moluccensis* (Lam.) Roem.
11.	STERCULIACEAE	25.	*Heritiera littoralis* (Dryand) Ait.

TABLE 1a

OTHER COMMON ASSOCIATED SPECIES WHICH ARE NOT TRUE MANGROVE OCCURRING ALONG THE INNERMOST MARGIN

S.N.	Family		Species
1.	FERN	1.	*Acrostichum aureum* L.
		2.	*A. speciosum* Wild.
2.	CAESALPINICEAE	3.	*Caesalpinia bonducella* Fleming
		4.	*C. nuga* Ait.
3.	VERBENACEAE	5.	*Clerodendrum inerme* Gaertn.
4.	LEGUMINOSAE	6.	*Derris scandens* Benth.
		7.	*Pongamia pinnata* Vent
		8.	*Afzelia bijuga* A. Gray
5.	MALVACEAE	9.	*Hibiscus tiliaceus* Linn.
		10.	*Thespesia populnea* (L.) Soland.
6.	RUBIACEAE	11.	*Guettarda speciosa* Linn.
7.	APOCYNACEAE	12.	*Cerbera floribunda* K. Schum.
8.	BIGNONIACEAE	13.	*Dolichandrone rheedii* Seem.
9.	PANDANACEAE	14.	*Pandanus tectorius* Soland.
10.	PALMAE	15.	*Liacula spinosa* Warmb.

is irregular and deeply indented thereby giving rise to a number of tidal creeks. These creeks are densely populated by this peculiar plant community. Here the mangroves are well protected against heavy tidal action and some what sheltered from high wind. Most of the islands have muddy, sandy and to some extent muddy sandy soil type. These factors provide ideal conditions for mangrove development and establishment. Extensive survey of various Islands of south and Middle Andaman was done and we came to the conclusion that the mangrove Community of these islands is greatly dominated by the family Rhizophoraceae and the seaward line is always occupied by *Rhizophora* spp. We have collected a total of 40 species of mangroves belonging to 28 genera distributed over 20 families. Among these 25 species are exclusive species (Table 1). According to the latest census (COE 1983)

TABLE 2

FLORISTIC COMPOSITION OF MANGROVE FOREST AT VARIOUS SITES

S.N.	Name of the species	Occurrence of species at different sites											Presence Class
		1	2	3	4	5	6	7	8	9	10	Total %	
1.	*Acanthus ilicifolius*	–	x	x	–	x	x	x	–	–	–	50	3
2.	*A. ebracteatus*	–	x	x	–	–	–	x	–	–	–	30	2
3.	*Avicennia marina*	–	–	x	–	–	–	x	x	x	x	50	3
4.	*A. officinalis*	x	x	x	x	x	x	x	x	x	x	100	5
5.	*Aegiceras corniculatum*	–	–	–	–	–	–	x	–	x	–	20	1
6.	*Bruguiera gymnorhiza*	x	x	x	x	x	x	x	x	x	x	100	5
7.	*B. parviflora*	–	–	x	–	x	x	–	–	–	–	30	2
8.	*B. cylindrica*	–	–	x	–	x	x	–	–	x	x	50	3
9.	*B. sexangula*	–	–	–	x	–	–	–	–	–	–	10	1
10.	*Ceriops tagal*	x	x	x	x	x	x	x	x	x	x	100	5
11.	*Rhizophora apiculata*	x	x	x	x	x	x	x	x	x	x	100	5
12.	*R. mucronata*	x	x	x	x	x	x	x	x	x	x	100	5
13.	*R. stylosa*	–	–	x	x	–	–	–	–	x	–	30	2
14.	*R. lamarckii*	–	–	–	–	–	–	–	–	–	x	10	1
15.	*Excoecaria agallocha*	–	–	x	–	–	–	x	–	–	–	20	1
16.	*Lumnitzera littorea*	–	–	x	–	x	–	x	x	x	–	50	3
17.	*L. racemosa*	–	x	x	–	–	–	–	–	–	–	20	1
18.	*Nypa fruticans*	–	–	x	–	x	–	x	x	–	x	50	3
19.	*Phoenix paludosa*	–	–	–	–	–	–	x	–	x	x	30	2
20.	*Scyphiphora hydrophyllacea*	–	x	–	–	x	–	x	x	x	–	50	3
21.	*Sonneratia alba*	–	–	x	x	–	–	–	–	–	–	20	1
22.	*S. apetala*	–	x	–	–	–	–	–	–	–	–	10	1
23.	*Xylocarpus granatum*	x	–	–	–	–	x	x	x	–	x	50	3
24.	*X. moluccensis*	x	–	–	–	–	–	–	–	–	x	20	1
25.	*Heritiera littoralis*	x	–	x	x	x	–	x	x	x	–	70	4
Total number of species at various sites.		8	10	17	9	12	9	16	11	13	12		
% Contribution		32	40	68	36	48	36	64	44	52	48		

there are 60 exclusive species distributed over 16 families confined to mangrove habitat only 23 non-exclusive species which occur in that habitat and elsewhere also. We have noted 15 non-exclusive species at various sites in the Andamans (Table 1a).

From Table 2 it is seen that some species, e.g. *Rhizophora apiculata, R. mucronata, Ceriops tagal, Bruguiera gymnorhiza* and *Avicennia officinalis* are common to all sites. Sites 3 and 7 are very rich in floristic composition, contributing 68% and 64% of the total mangrove species respectively.

Index of similarity among 10 sites were analysed (Table 3). From the table it is seen that maximum similarity is present between mangals of site-3 and site-7 and minimum between those of site-6 and site-7.

TABLE 3

SIMILARITY INDEX AT DIFFERENT MANGROVES SITES

Sites	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 7	Site 8	Site 9	Site 10
Site-1	1.0	58.82	48.79	57.14	43.75	78.28	50.00	48.22	43.75	50.00
Site-2		100	51.28	46.15	53.33	46.15	42.85	51.85	46.66	53.33
Site-3			100	54.54	69.45	47.05	87.14	52.94	64.84	59.45
Site-4				100	50.00	38.09	68.88	67.12	58.35	41.66
Site-5					100	50.00	45.00	64.00	64.28	42.85
Site-6						100	33.33	54.84	48.00	64.00
Site-7							100	59.45	60.00	50.00
Site-8								100	72.00	72.00
Site-9									100	64.28
Site-10										100

TABLE 4

*COMPLEXITY INDEX OF VARIOUS SITES OF ANDAMAN ISLANDS

S.N.	Site	No. of species	No. of trees above 10 cm diam.	Height in m	Basal area in m	Complexity index	Rainfall in mm
1.	Alexandra Island	8	90	8.7	1.51	9.45	2286
2.	Wandoor	10	102	10.0	1.40	14.28	2286
3.	Carbynscove	17	80	7.7	0.91	9.52	2286
4.	Chiriyatapu	9	120	7.7	4.93	40.99	2212
5.	Wrightmyo	12	160	9.3	2.43	43.3	2417
6.	Bambooflat	9	157	9.0	1.75	22.25	2417
7.	Oralkatcha	16	175	17.0	6.95	330.82	3429
8.	Nilamboor	11	131	12.7	5.64	103.21	3429
9.	Gandhijetty	13	180	12.6	3.15	92.87	3429
10.	Kadamtala	11	163	12.0	4.68	100.69	2810

* Complexity index is for function of no. spp., density, basal area, height and factor 10^{-3} based on 0.1 ha.

Complexity index: Is a very simple mathematical expression for the quantitative characters of the community in term of complexity index. The coefficient was used originally only for comparing the floras of larger areas in relation to rainfall. Holdridge (1967) gave the idea of complexity index in case of mangrove forest. We have determined the complexity index of all the 10 sites (Table 4). Maximum complexity index has been noted at

TABLE 5

STRUCTURE OF MANGROVE AND RAINFALL (BASED ON 0.1 HA. AREA)

Country	No. of spp.	No. of trees above 10 cm diam.	Basal area in m	Height in m	Complexity Index	Rain fall mm
Costa Rica (Main river)	4	118	9.53	16.0	72.0	3300
Costa Rica (Santa rosa)	2	80	2.22	10.0	3.6	1800 (6 months dry)
Puerto Rico (Mona Island)	2	179	2.97	15.0	15.9	1631
Puerto Rico	2	17	0.17	4.8	1	860
Andaman South	9	120	7.7	4.93	40.99	2286
Andaman middle	16	175	17.0	6.95	330.82	3429

TABLE 6

GENERAL STRATIFICATION OF SPECIES IN THE MANGROVE FOREST OF ANDAMAN ISLANDS

Stratum 1 Trees or tall shrubs abundant and contributing to the physiognomy of the association.	Stratum 2 Shrubs or small trees which may be locally abundant.	Stratum 3 Low shrubs or lianas frequently present in edaphically restrictive situations.
Outer		
1. INNER ZONE:		
Rhizophora mucronata	*Ceriops tagal*	
R. apiculata	*Bruguiera parviflora*	
R. stylosa	*Aegiceras corniculatum*	
Ceriops tagal		
Avicennia marina		
A. officinalis		
2. MIDDLE ZONE:		
Bruguiera gymnorhiza	*Excoecaria agallocha*	*Acanthus ebracteatus*
B. parviflora		*A. ilicifolius*
Sonneratia alba		
Lumnitzera littorea		
Xylocarpus granatum		
X. moluccensis		
3. DISTAL ZONE:		
Heritiera littoralis	*Phoenix paludosa*	*Nypa fruticans*

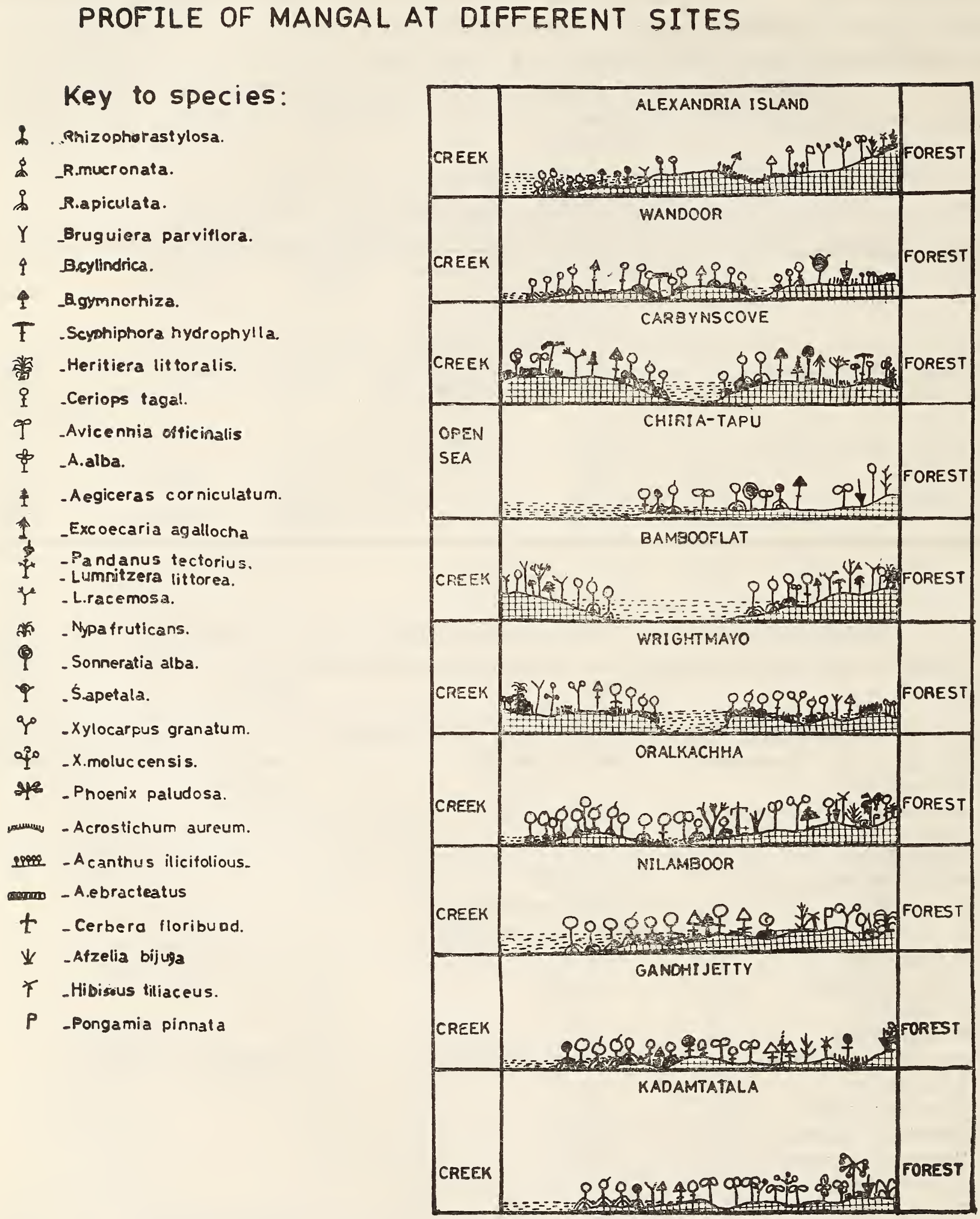
PROFILE OF MANGAL AT DIFFERENT SITES
Key to species:
Rhizophorastylosa.
R.mucronata.
R.apiculata.
Bruguiera parviflora.
B.cylindrica.
B.gymnorhiza.
Scyphiphora hydrophylla.
Heritiera littoralis.
Ceriops tagal.
Avicennia officinalis
A.alba.
Aegiceras corniculatum.
Excoecaria agallocha
Pandanus tectorius.
Lumnitzera littorea.
L.racemosa.
Nypa fruticans.
Sonneratia alba.
S.apetala.
Xylocarpus granatum.
X.moluccensis.
Phoenix paludosa.
Acrostichum aureum.
Acanthus ilicifolious.
A.ebracteatus
Cerbera floribund.
Afzelia bijuga
Hibiscus tiliaceus.
Pongamia pinnata
ALEXANDRIA ISLAND
CREEK
FOREST
WANDOOR
CREEK
FOREST
CARBYNSCOVE
CREEK
FOREST
CHIRIA-TAPU
OPEN SEA
FOREST
BAMBOOFLAT
CREEK
FOREST
WRIGHTMAYO
CREEK
FOREST
ORALKACHHA
CREEK
FOREST
NILAMBOOR
CREEK
FOREST
GANDHI JETTY
CREEK
FOREST
KADAMTATALA
CREEK
FOREST

Fig. 2.

Oralkatcha (Baratang Island), the value is 330.82 and minimum is at Carbynscove the value is 9.52. The high value of complexity index at Oralkatcha is due to high rainfall and the undisturbed condition of the mangroves forest. There is no felling, while at other sites of South Andamans complexity index is generally low, this may be due to the low rainfall and high human interference in these islands. At sites-1 and 2, felling in many places is so common that whole areas are devoid of vegetation and there are no natural regeneration, resulting in change of the basic structural pattern of mangrove forest. A comparative complexity index has been given in Table 5, from the table it is seen that mangroves of Andaman Islands are richer and healthier in comparison to mangroves of Costa-Rica and Puerto-Rico.

Stratification: The structure that results from the distribution of organism and their interaction with their environment can be called pattern. Many different kinds of arrangement in the standing crop of organisms contribute to pattern diversity in the community as for example: 1. Stratification pattern (vertical layering), 2. Zonational pattern, 3. Activity pattern, 4. Food web pattern, 5. Reproductive pattern etc. In all, stratification pattern is most important pattern for the study of any forest. In a forest the two basic layers the autotrophic and heterotrophic strata- that are characteristic of all communities are frequently distinctly stratified into additional layers.

In the case of the mangrove forests of Andamans there is layering but the layering is not as clear as is found in the beach forests or evergreen forests of the Andamans. In some places where the mangrove forest is well developed and there is no interference of biotic factors, e.g. Kadamtala, Gandhi Jetty and Oralkatcha, the height of many trees, e.g. *Bruguiera gymnorhiza, Lumnitzera littorea, Avicennia marina* and *Rhizophora mucronata* and *R. apiculata* reaches to 30 to 45 metres.

We have noted three strata in case of mangrove forests of Andamans:

Upper stratum — occupied by tall mangrove species, e.g. *Bruguiera gymnorhiza, Lumnitzera, littorea, Rhizophora mucronata, R. apiculata* etc.

Middle stratum — Occupied by shrubs and small trees which are abundant in middle zone, e.g. *Ceriops tagal, Excoecaria agallocha, Aegiceras corniculatum, Bruguiera parviflora,* etc.

Lower stratum — It is occupied by small shrubs and fern, e.g. *Acanthus ebracteatus, A. ilicifolius, Nypa fruticans,* etc.

Zonational trends of mangrove swamp of Andaman: Based on the study of the structure and composition of mangrove forest at different sites the following 7 major types of mangrove communities are recognised:

1. *Rhizophora mucronata — Rhizophora apiculata* Community
2. *Bruguiera gymnorhiza — Ceriops tagal* Community
3. *Rhizophora mucronata — Bruguiera gymnorhiza* Community
4. *Lumnitzera littorea — Avicennia officinalis* Community
5. *Bruguiera gymnorhiza — Avicennia officinalis* Community
6. *Heritiera littoralis — Pongamia pinnata* Community
7. *Acanthus ilicifolius — Acrostichum aureum* Community

Rhizophora species grows typically on the outer seaward (fig. 2) fringe of the swamp, where the water is most salty. The distribution of species in such habitat is largely controlled by salinity of substratum, frequency and duration of flooding by tide water, and moisture content of substratum. Zonational pattern of

TABLE 7

ECOLOGICAL DISTRIBUTION PATTERN OF MANGROVES AT DIFFERENT SITES IN RELATION TO HABITATS

S. No. Sites	Habitat	Proximal Zone-A zone of pure patch of mangrove	Middle Zone-A zone of mixed mangrove	Distal zone-A zone of border line mangrove
A) *South Andaman* 1) Alexandra Island	Sandy	Length: 10-20 m patch of mangrove *R. apiculata* *Ceriops tagal* *Avicennia officinalis*	Length: 40-50 m Zone not clear occupied by *Ceriops tagal, Bruguiera gymnorhiza, Xylocarpus granatum, X. moluccensis* *Clerodendrum inerme*	Length: 10-50 m *Heritiera littoralis* *Hibiscus tiliaceus,* *Pandanus tectorius* *Acrostichum aureum*
2) Wandoor	Sandy muddy	Length: 10 m *Rhizophora mucronata,* *R. apiculata* *Sonneratia apetala*	Length: 30-60 m *Ceriops tagal,* *Bruguiera gymnorhiza* *Scyphiphora hydrophyllacea,* *Lumnitzera racemosa,* *Guettarda speciosa*	Length: 20-25 m *Acrostichum aureum* *Acanthus ilicifolius* *Pandanus tectorius* *Cacsalpinia nuga*
3) Carbynscove	Sandy clayey	Length: 5-15 m *Rhizophora mucronata* *R. apiculata,* *R. stylosa,* *Sonneratia alba*	Length: 30-60 m *Avicennia marina,* *A. officinalis,* *Bruguiera gymnorhiza* *B. parviflora,* *B. cylindrica,* *Aegiceras corniculatum* *Lumnitzera littorea,* *L. racemosa,* *Excoecaria agallocha*	Length: 20 or greater m *Hibiscus tiliaceus,* *Acrostichum aureum,* *Nypa fruticans,* *Acanthus ilicifolius,* *Heritiera littoralis*
4) Chiriyatapu	Rocky stony	Length: not clear *Rhizophora mucronata,* *R. apiculata,* *R. stylosa, Ceriops tagal, Bruguiera gymnorhiza,* *Sonneratia apetala*	Length: 20-40 m *Ceriops tagal,* *Bruguiera gymnorhiza,* *Avicennia officinalis,* *R. stylosa,*	Length: 5-10 m *Hibiscus tiliaceus,* *Heritiera littoralis,* *Pandanus tectorius*
5) Bambooflat	Muddy	Length: 30-40 m *Rhizophora mucronata,* *R. apiculata*	Length: 60-90 m *Avicennia officinalis,* *Bruguiera gymnorhiza* *B. cylindrica,* *B. parviflora,* *Ceriops tagal*	Length: 15-20 m *Acanthus ilicifolius* *Nypa fruticans* *Heritiera littoralis* *Caesalpinia nuga* *C. bonducella*
6) Wrightmyo	Muddy sandy	Length 25-40 m *Rhizophora mucronata* *R. apiculata,* *Avicennia officinalis,*	Length: 50-70 m *Bruguiera parviflora* *B. cylindrica, B. gymnorhiza,* *Xylocarpus granatum,*	Length: 15-20 m *Acanthus illicifolius,* *Acrostichum aureum,* *Heritiera littoralis,*

TABLE 7 (contd.)

S. No.	Sites	Habitat	Proximal Zone-A zone of pure patch of mangrove	Middle Zone-A zone of mixed mangrove	Distal zone-A zone of border line mangrove
			Ceriops tagal	*X. moluccensis.* *Ceriops tagal, Dolichandrone rheedii*	
B)	*Baratang Islands*				
7)	Oralkatcha	Muddy	Length 50-60 m *Rhizophora mucronata,* *R. apiculata*	Length: 100-150 m *Rhizophora mucronata,* *R. apiculata,* *Avicennia officinalis,* *A. marina, B. gymnorhiza,* *Ceriops tagal, Scyphiphora hydrophyllacea, Aegiceras corniculatum,* *Afzelia bijuga,* *Lumnitzera littorea* *Cerbera floribunda,* *Excoecaria agallocha,* *Xylocarpus granatum,* *X. moluccensis*	Length: 20-35 m *Licula spinosa, Phoenix paludosa,* *Heritiera littoralis* *Pongamia pinnata,* *Thespesia populnea* *Pandanus tectorius* *Acrostichum aureum,* *Dolichandrone rheedii* *Clerodendrum inerme* *Hibiscus tiliaceus*
8)	Nilamboor	Muddy	Length: 40-60 m *Rhizophora mucronata,* *R. apiculata*	Length: 80-130 m *Bruguiera gymnorhiza,* *Ceriops tagal, R. apiculata,* *R. mucronata, Scyphephora hydrophyllacea.*	Length: 20-35 m *Nypa fruticans,* *Heritiera littorea,* *Acrostichum aureum*
9)	Gandhijetty	Muddy	Length: 30-35 m *Rhizophora mucronata,* *R. apiculata* *Avicennia marina*	Length: 60-120 m *Bruguiera parviflora,* *B. gymnorhiza, B. cylindrica,* *Ceriops tagal, Avicennia marina,* *A. officinalis, Scyphiphora Hydrophyllacea,* *Aegiceras corniculatum,* *Dolichandrone rheedii*	Length: 20-25 m *Heritiera littoralis* *Phoenix paludosa,* *Acrostichum aureum*
C)	*Middle Andaman*				
10)	Kadamtala	Muddy	Length: 15-25 m *Rhizophora apiculata* *R. mucronata*	Length: 72-130 m *Avicennia officinalis* *A. marina, R. mucronata,* *B. gymnorhiza, B. parviflora,* *B. cylindrica, Ceriops tagal,* *Xylocarpus granatum* *X. moluccensis,* *Aegiceras corniculatum*	Length: 15-20 m *Phoenix paludosa,* *Acrostichum aureum* *Nypa fruticans,* *Acanthus ilicifolius*

TABLE 7

ECOLOGICAL DISTRIBUTION PATTERN OF MANGROVES AT DIFFERENT SITES IN RLLATION TO HABITATS

S. No.	Sites	Habitat	Proximal Zone-A zone of pure patch of mangrove	Middle Zone-A zone of mixed mangrove	Distal zone-A zone of border line mangrove
A) 1)	*South Andaman* Alexandra Island	Sandy	Length: 10-20 m patch of mangrove *R. apiculata* *Ceriops tagal* *Avicennia officinalis*	Length: 40-50 m Zone not clear occupied by *Ceriops tagal, Bruguiera gymnorhiza, Xylocarpus granatum, X. moluccensis* *Clerodendrum inerme*	Length: 10-50 m *Heritiera littoralis* *Hibiscus tiliaceus,* *Pandanus tectarius* *Acrostichum aureum*
2)	Wandoor	Sandy muddy	Length: 10 m *Rhizaphora mucronata,* *R. apiculata* *Sonneratia apetala*	Length: 30-60 m *Ceriops tagal,* *Bruguiera gymnorhiza* *Scyphiphora hydrophyllacea,* *Lumnitzera raccmosa,* *Guettarda speciasa*	Length: 20-25 *m* *Acrostichum aureum* *Acanthus ilicifolius* *Pandanus tectorius* *Caesalpinia nuga*
3)	Carbynscove	Sandy clayey	Length: 5-15 *m* *Rhizophora mucronata* *R. apiculata,* *R. stylosa,* *Sonneratia alba*	Length: 30-60 m *Avicennia marina,* *A. officinalis,* *Bruguiera gymnorhiza* *B. parviflora,* *B. cylindrica,* *Aegiceras corniculatum* *Lumnitzera littorea,* *L. racemosa,* *Excoecaria agallocha*	Length: 20 or greater m *Hibiscus tiliaceus,* *Acrostichum aureum,* *Nypa fruticans,* *Acanthus ilicifolius,* *Heritiera littoralis*
4)	Chiriyatapu	Rocky stony	Length: not clear *Rhizophora mucronata,* *R. apiculata,* *R. stylosa, Ceriops tagal, Bruguiera gymnorhiza,* *Sonneratia apetala*	Length: 20-40 m *Ceriops tagal,* *Bruguiera gymnorhiza,* *Avicennia officinalis,* *R. stylosa.*	Length: 5-10 m *Hibiscus tiliaceus,* *Heritiera littoralis,* *Pandanus tectorius*
5)	Bamboofiat	Muday	Length: 30-40 m *Rhizophora mucronata,* *R. apiculata*	Length: 60-90 m *Avicennia afficinalis,* *Bruguiera gymnorhiza* *B. cylindrica,* *B. parviflora,* *Ceriops tagal*	Length: 15-20 m *Acanthus ilicifolius* *Nypa fruticans* *Heritiera littoralis* *Caesalpinia nuga* *C. bonducella*
6)	Wrightmyo	Muddy sandy	Length 25-40 m *Rhizophora mucronata* *R. apiculata,* *Avicennia officinalis,* *Ceriops tagal*	Length: 50-70 m *Bruguiera parviflora* *B. cylindrica, B. gymnorhiza.* *Xylocarpus granatum,* *X. moluccensis,* *Ceriops tagal, Dolichandrone rheedii*	Length: 15-20 m *Acanthus illicifolius,* *Acrostichum aureum,* *Heritiera littoralis,*
B)	*Baratang Islands*				
7)	Oralkatcha	Muddy	Length 50-60 m *Rhizophora mucranata,* *R. apiculata*	Length: 100-150 m *Rhizaphara mucranata,* *R. apiculata,* *Avicennia officinalis,* *A. marina, B. gymnorhiza,* *Ceriops tagal, Scyphiphora hydrophyllacea, Aegiceras carniculatum,* *Afzelia bijuga,* *Lumnitzera littarea* *Cerbera floribunda,* *Excoecaria agallocha,* *Xylocarpus granatum,* *X. maluccensis*	Length: 20-35 m *Licula spinosa, Phoenix paludosa,* *Heritiera littoralis* *Pongamia pinnata,* *Thespesia populnea* *Pandanus tectorius* *Acrostichum aureum,* *Dolichandrone rheedii* *Clerodendrum inerme* *Hibiscus tiliaceus*
8)	Nilamboor	Muddy	Length: 40-60 m *Rhizophora mucronata,* *R. apiculata*	Length: 80-130 m *Bruguiera gymnorhiza,* *Ceriaps tagal, R. apiculata,* *R. mucronata, Scyphephora hydrophyllacea.*	Length: 20-35 *m* *Nypa fruticans,* *Heritiera littorea,* *Acrostichum aureum*
9)	Gandhijetty	Muddy	Length: 30-35 m *Rhizophora mucronata,* *R. apiculata* *Avicennia marina*	Length: 60-120 m *Bruguiera parviflora,* *B. gymnorhiza, B. cylindrica,* *Ceriops tagal, Avicennia marina,* *A. officinalis, Scyphiphora Hydrophyllacea,* *Aegiceras carniculatum,* *Dolichandrone rheedii*	Length: 20-25 m *Heritiera littoralis* *Phoenix paludosa,* *Acrostichum aureum*
C)	*Middle Andaman*				
10)	Kadamtala	Muddy	Length: 15-25 *m* *Rhizophora apiculata* *R. mucronata*	Length: 72-130 m *Avicennia officinalis* *A. marina, R. mucronata,* *B. gymnorhiza, B. parviflora,* *B. cylindrica, Ceriops tagal,* *Xylocarpus granatum* *X. moluccensis,* *Aegiceras corniculatum*	Length: 15-20 m *Phoenix paludosa,* *Acrastichum aureum* *Nypa fruticans,* *Acanthus ilicifolius*

mangroves of all sites have been studied and is given in Table 7. From the table, it is seen that mangroves of all sites have three zonation, namely Proximal zone, middle zone and distal zone.

Proximal zone: This is the seaward zone where frequency of inundation is maximum. The species in this zone are *Rhizophora apiculata, R. mucronata, Ceriops tagal, Sonneratia alba*, etc. Salinity is in neighbourhood of that of sea water.

Middle Zone: This zone is towards the interior, soluble salts are more than in sea water. The common species are *Bruguiera* spp. having great girth. *Lumnitzera littorea, Aegiceras corniculatum*, etc. usually they attained great height and girth.

Distal Zone: This zone is towards landward fringe, where salinity may be high. The common species are *Heritiera littoralis, Acrostichum aureum, Acanthus* species, etc. This type of zonational pattern is called metabolic zonation. From water edge to inland, a pattern of change in soil salinity and corresponding zonation of the mangrove species is usually observed. Each species occupies a salinity zone to which it is best adapted; more of the energy goes to growth and less to maintenance (i.e. respiration) as compared to potential competitor species. This adaptation to salinity regime is known as the metabolic zonation. Mangroves such as *Avicennia, Aegiceras* and *Aegialitis* have salt secreting glands on their leaves. The sap which passes up their xylem contains 0.2-0.5% Sodium Chloride. Mangroves such as *Rhizophora, Bruguiera* and others lack the salt secreting glands and the concentration of salt in their sap is only about 1/10 of the above group. They have an ultra-filtration mechanism in their roots enabling selection absorption of ions.

In some species, e.g. *Sonneratia* and others have been found to have excessive amount of ions in their organs and thus with the absorbed and accumulated ions the leaves become quite fleshy. In all cases the osmotic pressure of cell sap is now near that of sea water. The normal process of transpiration accounts for flow of water through the plant. The main difference between mangroves and other plants is that the mangroves have an usually high osmotic pressure in the leaf cell sap. It seems that physiologically salt excluding membrane system is more efficient than the system having salt secreting gland on their leaves. The occurrence of *Rhizophora* spp. in proximal zone or at seaward side at various study sites supports this idea. Other species like — *Avicennia, Aegiceras* and *Lumnitzera* sp. are always recorded in the middle zone of the mangrove forest, where soluble salts are more.

From the zonational study it seems that habitat if sandy and not flat has less species composition and less zonational pattern. Those areas which are flat and muddy have greater number of species composition and broad zonational pattern.

SUMMARY

Ecological studies of mangrove forest were undertaken at 10 sites covering a large area of mangrove forests of the Andaman Islands. Forty species belonging to 28 genera, of over 20 families have been recorded. Complexity index of each site has been determined. Mangroves of middle Andaman have more complexity index than south Andaman. Zonational pattern of mangrove species at different sites was studied. It is seen that each species usually occupies a salinity zone to which it is best adapted.

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SURVEY OF THE FRESHWATER TURTLES OF INDIA
PART I: THE GENUS *KACHUGA*[1]

Edward O. Moll[2]

(*With a colour plate and eight text-figures*)

Kachuga is the most diverse genus of the Asiatic batagurines. This paper recognizes 7 species and 10 subspecies (one new and one resurrected). All but one occur in India. Egg shell and penial morphology support a close relationship of *Kachuga* to *Batagur, Callagur, Hardella,* and *Morenia.* Two distinct species' groupings evident within the genus are tentatively designated the subgenera *Kachuga* and *Pangshura.* The former contains the larger (>40 cm CL) species, *K. dhongoka* and *K. kachuga*; the latter includes the smaller (< 30 cm CL), *K. smithii, K. sylhetensis, K. tecta* and *K. tentoria.* Sexual dimorphism in size characterizes both groups but pronounced sexual dichromatism is known only in the *Kachuga.* Members of both subgenera are highly aquatic, herbivorous species but differ in other aspects of their ecology. Members of the subgenus *Kachuga* are inhabitants of moderate to large rivers, nesting on sand banks chiefly in March and April. Members of the *Pangshura* inhabit lentic as well as lotic habitats and nest in the winter months of October through January in a variety of situations.

Keys and descriptions are provided for identifying each species and subspecies. Verified locality records are plotted on distribution maps.

INTRODUCTION

India boasts one of Asia's most diverse assemblages of chelonians. At least 5 families, 23 genera and 31 species occur within the boundaries of the country. Generally the distribution and the biology of these species are poorly known. Much of our knowledge of this assemblage comes from writings of the British naturalists of the nineteenth and early twentieth century. For the most part these men were concerned only with taxonomy. Their locality data were seldom precise (e.g. North India, Peninsular India) and natural history data were rarely provided. To further complicate matters much of the describing and classifying was done by museum curators such as John Edward Gray, Albert Guenther, and George Albert Boulenger who had never been to India and who often relied on second hand information, drawings and dried specimens to prepare their accounts. Considerable confusion and lengthy synonomies have resulted. Malcolm Smith's 1931 treatise on chelonians in *The Fauna of British India* series did much to summarize the available information and to reduce confusion. Nevertheless the distributions given were still sketchy and little natural history information was provided.

A long lapse followed Smith's work during which time there was meagre interest in field biology of turtles particularly freshwater species. With a few exceptions (e.g. Acharji

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1950, 1955, Hora 1948, Jayaram 1974) only a scattering of small notes concerning freshwater chelonians appeared in the Indian journals from the thirties to the eighties. Interest was rekindled by conservation concerns of the IUCN (International Union for Conservation of Nature and Natural Resources). Meeting in conjunction with the 1981 Convention on International Trade in Endangered Species (CITES) in New Delhi, the newly formed Freshwater Chelonian Specialist Group (FCSG) of the IUCN noted that a proportionately large number of the chelonians listed on CITES Appendices I & II (endangered and threatened categories) inhabited India and Bangladesh. It also noted that there were few data concerning the status and distribution of these species in the region. A survey of the freshwater chelonians of India to obtain data on their distribution and conservation status was given a "highest priority" status for action by the group.

The initial survey of the Indian chelonians was funded by a grant from World Wildlife Fund to Rom Whitaker and me and was carried out by Ms. J. Vijaya in West Bengal and adjoining states from August 1981 to February 1982. This was followed by a more extensive survey of Indian rivers and markets from September 1982 to June 1983 conducted by myself, Vijaya and Satish Bhaskar with funding from an Indo-American Fellowship. Some of the findings of these surveys have now been published or are accepted for publication (Groombridge *et al.* 1983; Moll 1983, 1984, 1985, in press a, b, c.). Publicity about these surveys and the plight of the South Asian chelonians in general helped to spark the interest of other investigators, contributing to a flurry of recent publications (many conservation oriented) concerning these species (e.g. Das 1986, Khan 1982, Rao and Singh 1984, 1985; Vijaya 1982a, b, c, d, e, f, g, h, i, j, 1983a, b, c, d, e; Whitaker 1982, and Yadava and Prasad 1982a, b).

This paper begins a several part series aimed at incorporating the findings of the aforementioned surveys with recent information from other authors to provide an updated account concerning identification, distribution and biology of the Indian freshwater chelonian fauna. This part considers the Indian representatives of the most diverse genus of Asiatic batagurines, the *Kachuga.*

METHODS

In the course of our surveys, we visited 14 major rivers: the Ganges and its tributaries (the Hindon, Yamuna, Chambal, Ghagra, Rapti, Gandak and Hooghly) along with the Subharnareka, Mahanadi, Godavari, Cauvery, Narmada and Tapti. Typical procedure of these surveys included sampling available habitats with baited hoop traps (Legler 1960) and trammel nets, contacting fishermen and market vendors for information and specimens, and canvassing garbage dumps for skeletal material. Voucher specimens for most localities have been placed in the collections of the Bombay Natural History Society (BNHS) or the Field Museum of Natural History in Chicago (FMNH). A few have been kept alive for captive breeding purposes at the Madras Crocodile Bank. Others are in the author's possession (EOM).

Specimens were measured with aluminium forestry calipers, weighed with portable spring scales and described before being preserved or released. Standard measurements, given in centimeters unless otherwise indicated, are maximum carapace length (CL), carapace width (CW), plastron length (PL) and height of shell (H). Color descriptions of living specimens were made using color swatches of Smithe (1975). Scute and bone terminology of the shell follows Zangerl (1969). Common names follow Iverson (1985) except that terrapin has been substituted for turtle in the *Kachuga* to be consistent with the names of close relatives (painted terrapins — *Callagur*; river terrapins — *Batagur*).

Keys, descriptions and colored photographs showing ontogenetic and sexual variation are provided herein to facilitate identification. To save space in the descriptions certain forms of abbreviation have been used requiring explanation: The seam contact formula indicates where the seams of the pleural scutes contact the marginals. The abbreviations used are modified from that of Tinkle (1962). Five pleural or carapacial seams contact the marginal scutes. The anterior edge of the first pleural typically contacts the first marginal. To indicate whether this contact is usually in the anterior, middle or posterior third of the marginal scute, the respective designations of 1<, 1M, or 1> are used. The formula 1M 4> 6> 8M 11< indicates that the five contacts were middle third of Marginal 1, posterior third of Marginals 4 and 6, middle third of Marginal 8 and anterior third of Marginal 11.

The neural formula signifies the number of sides on each of the eight neurals (i.e. 4, 6, or 8). For hexagonal neurals the symbols > and < denote whether the short sides of the bone are located anteriorly or posteriorly (see Fig. 3). When the number of sides is highly variable a range is given (e.g. 4-6).

The plastral formula indicates relative lengths of the plastral scutes along the midline of adults (juveniles often differ). Scute abbreviations are: G = gular, H = humeral, P = pectoral, Ab = abdominal, F = femoral, and A = anal. The signs >, <, and >< connote respectively — greater than, less than, and either may be the larger.

Other abbreviations include: RCM — Relative clutch mass (modified from Vitt and Price 1982) is the ratio of clutch mass to body mass of the spent female. ELI — Egg length index is the ratio of mean egg length to carapace length × 100. EWI — Egg width index is the ratio of mean egg width to carapace length x 100. EMI — Egg mass index is ratio of mean egg weight to body mass x 100. AP, MP, and UP are used to indicate the states of Andhra Pradesh, Madhya Pradesh and Uttar Pradesh in localities.

In addition to specimens collected on the surveys, I was able to examine the collections of chelonians in the Bombay Natural History Society (all), the Zoological Survey of India in Calcutta (part) and the British Museum of Natural History (BMNH) in London (part). When positive identification of specimens with seemingly accurate locality data was possible, I have included these in the 'Distribution' section to increase the number of reliable records available for the country.

RELATIONSHIPS

The *Kachuga* are members of the subfamily Batagurinae of the family Emydidae sensu McDowell (1964). Hirayama (1984) and Gaffney (1984) support elevating the subfamily to familial rank.

The interfamilial relationships of the batagurines are still being debated. See for example McDowell (1964), Carr (1981), Sites *et al.* (1984) and Hirayama (1984). My own studies of the penis and eggs (see below) support the scheme of Hirayama which considers *Kachuga* most closely related to *Batagur*, *Callagur*, *Hardella*, and *Morenia*. This is also similar to the view expressed by Loveridge and Williams (1957). All of these genera comprise herbivorous and highly aquatic species. Morphological characteristics shared by this group include a large foramen orbitonasale, a broad secondary palate, serrated tomia, strong plastral buttresses, the entoplastron lying anterior to humero-pectoral sulcus, and fourth marginal scutes contacting the second pleural scutes.

All of the aforementioned genera share a distinctive penial morphology characterized by a highly elaborated plica media (Fig. 1). The lateral fold of the plica media is modified into two pairs of flaps — a proximal rounded pair with a more prominant, pointed pair distally. The smaller, lower medial fold is conspicuously triangular in shape. No other batagurines have yet been found with this unusual type of penis. The genus *Ocadia* shares the triangular shaped medial fold but the distal flaps of the lateral fold are neither well developed nor pointed.

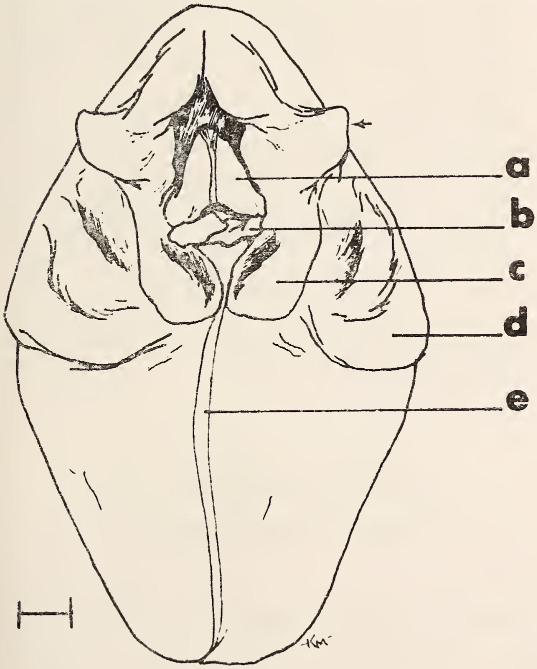


Fig. 1. Penis of *Kachuga kachuga*. Labled parts as follows: a. Plica media — medial fold. b. Plica interna. c. Plica media — lateral fold (small arrow indicates distinctive pointed flaps). d. Plica externa. e. Seminal groove. Scale marker represents 5 mm.

Ewert (1979) recognized three types of egg shells, brittle, hard-expansible and pliable. *Batagur*, *Callagur*, and *Kachuga* which lay hard-expansible to pliable-shelled eggs are the only batagurines thus far reported that do not lay brittle-shelled eggs. The egg shell type of *Hardella* and *Morenia* is unreported.

Within the genus *Kachuga*, there are two distinct species groups. One comprises the large, riverine species, *dhongoka*, *kachuga*, and *trivittata*. The other includes small to medium-sized turtles, *smithii*, *tecta*, *tentoria*, and *sylhetensis*, that inhabit rivers, nullahs and tanks. Gray (1855) recognizing the distinctness of the two groups placed them as subgeneric divisions (*Kachuga* and *Pangshura*) of the genus *Batagur*. Gunther (1864) and Gray (1869) elevated the *Pangshura* and *Kachuga* respectively to generic rank. Boulenger (1889) subsequently lumped both groups as the genus *Kachuga*. This arrangement which has lasted to present obscures the close relationship of the four smaller species which share a suite of derived characteristics not found in the larger forms. A tentative list of characters defining the two groups is provided in Table 1. The list is tentative as it is based chiefly on material collected by the survey and because no skeletons of *Kachuga sylhetensis* have been examined as yet. A larger study to determine the extent of geographical and individual variation in these characteristics is in progress.

For the purposes of this paper, the evolutionary divergence of these two lines is recognized by resurrecting *Pangshura* and *Kachuga* as subgenera of *Kachuga*.

TABLE 1

DIAGNOSTIC CHARACTERS OF THE SUBGENERA *Kachuga* AND *Pangshura*. NUMBERS IN ( ) INDICATE FIGURE NUMBERS DEPICTING EACH CHARACTER

Character	*Kachuga*	*Pangshura*
Upper Jaw (2)	Medial Notch, Weakly Bicuspid	Unnotched.
Neural Formula (3)	4, 6>6>6> 6>6>6>4 - 6>	4, 6>6>8, 4, 6>6>4-6>
Apex of Shell (4)	Vertebral 2	Vertebral 3
Fourth Vertebral Scute (5)	Broad Anteriorly, Overlaps 4 neurals	Narrow Anteriorly, Overlaps 5 Neurals
Costo-Peripheral Fontanelles (6)	Remain Prominant in Males	Fused by Maturity or Very Small
Carapace	Three Striped Or Unmarked	Usually Median Stripe Only
Maximum Size	> 40 cm CL	< 30 cm CL

KEY TO THE INDIAN SPECIES OF *Kachuga* (ADULTS)

1 Apex of shell at posterior of second vertebral (Fig. 4A); fourth vertebral contacts third broadly (Fig. 5A); upper mandible usually bicuspid with medial notch (Fig. 2A) .... (subgenus *Kachuga*) 2

1′ Apex of shell at posterior of third vertebral (Fig. 4B); fourth vertebral attenuated anteriorly, narrowly contacting third (Fig. 5B); upper mandible not bicuspid, lacks medial notch (Fig. 2B) .... (subgenus *Pangshura*) 3

2 Second vertebral pointed posteriorly (Fig. 5A); shell usually patterned with three-stripes, a distinct dark mid-dorsal stripe flanked by less distinct broken or continuous lateral stripes .... *K. dhongoka*

2′ Second vertebral not pointed posteriorly; shell lacks a distinct pattern .... *K. kachuga*

3 Fifth vertebral widest at anterior half of scute; usually 13 pairs of marginal scutes with those along posterior border strongly serrated .... *K. sylhetensis*

3′ Fifth vertebral widest at posterior half of scute; usually 12 pairs of nonserrated or weakly serrated marginal scutes present 4

4 Shell relatively low — maximum height usually less than 44% of maximum length; median keel of carapace with weak or no spine on third vertebral (when present not angled sharply upward) .... *K. smithii*

4′ Shell high vaulted — maximum height usually exceeds 45% of maximum length; median keel with prominant spine on third vertebral angled steeply upward (may be worn down in old individuals) 5

5 Head patterned with broad orange to red crescentic postocular bands which curve upward from under the eyes often merging to form a chevron at the back of the head; plastral pattern typically of multiple small dark blotches on each scute .... *K. tecta*

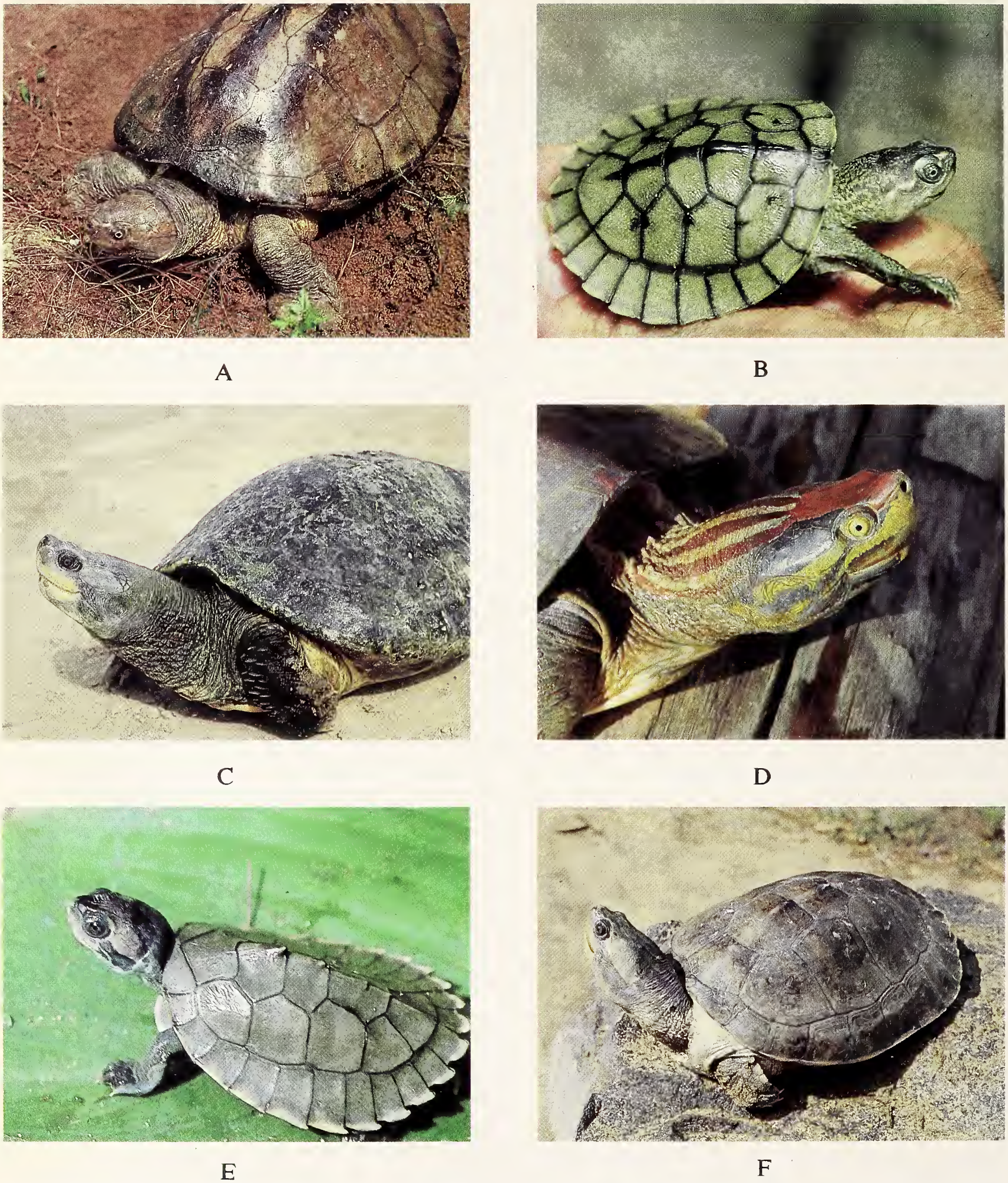
5′ Head pattern lacks broad crescentic band, one or two reddish to brownish postocular spots often present; plastron with a single, large dark blotch per scute or unmarked ..... *K. tentoria*

SPECIES ACCOUNTS

Genus *Kachuga* Gray 1855

Indian Roofed Terrapins

Distributed from Pakistan to Burma, the genus contains seven species and ten subspecies, all but one of which occurs in India. Roofed turtles can be distinguished from other batagurines by an elongated fourth vertebral scute which covers all or part of at least four neural bones.



(A) *Kachuga dhongoka* — Female (36.9 cm CL) purchased in Calcutta market. (B) *K. dhongoka* — Hatchling (5.3 cm CL) from eggs collected on sand banks of the Chambal River near Bah, U.P. (C) *K. kachuga* — Female (48.4 cm CL) from Yamuna River, at Bateshwar, U.P. (D) *K. kachuga* — Male (29.0 cm CL) from the Chambal River near Barenda, M.P. (E) *K. kachuga* — Hatchling (6.0 cm CL) from eggs collected on sand banks of the Chambal River near Bah, U.P. (F) *K. kachuga* — Immature female (20.5 cm CL) from the Yamuna River at Bateshwar, U.P.

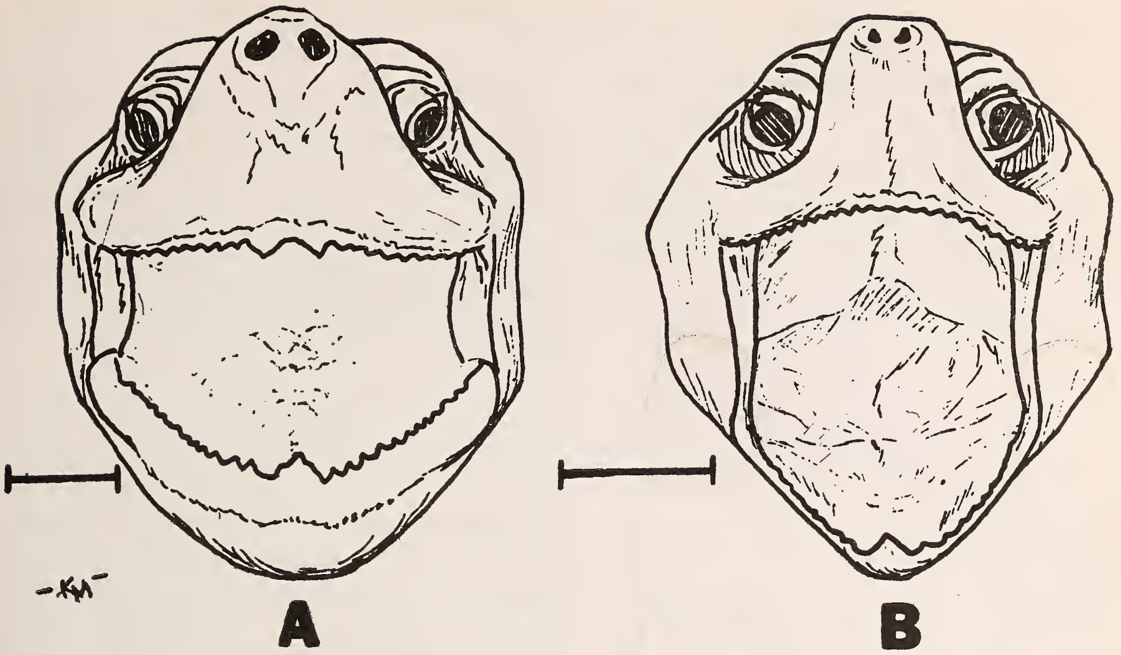


Fig. 2. Anterior view of the heads of *Kachuga kachuga* (A) and *K. tentoria* (B). Note weak bicuspid condition with slight medial notch in A and its absence in B. Scale marker represents 1 cm.

Description: Small to large (56 cm CL) aquatic turtles having serrated jaws; an expanded secondary palate bearing one or two denticulated ridges; a large foramen orbitonasale exceeding many times the diameter of the posterior palatine foramen; the fourth marginal scute contacting the second pleural scute; expanded plastral buttresses in which the anterior contacts the first rib and the posterior the fifth and sixth costals near the neural suture; the entoplastron positioned anterior to the humero-pectoral suture; narrow band-like scales on the limbs; and fully webbed feet with five clawed toes on the forefeet and four on the hind feet.

Subgenus *Kachuga*

Contains three species — *dhongoka, kachuga,* and *trivittata* (from Burma). For the most part this subgenus is diagnosed by plesiomorphic or primitive characteristics shared with sister groups such as *Hardella* and *Callagur* (see Table 1 and Figs. 2-6). They are large riverine species showing moderate sexual dimorphism and with the exception of *dhongoka,* pronounced sexual dichromatism.

Kachuga dhongoka (Gray 1834)

Three -striped Roofed Terrapin — Plate I, A+B

Identification: A large riverine *Kachuga* (upto 48 cm CL) identifiable by a single denticulated ridge on the palate, a pattern of three stripes (may be obscure) on the carapace and a posteriorly pointed second vertebral scute in adults.

Description: Sexes colored similarly (BNHS 1343 and FMNH 224136); carapace — brownish olive, olive gray or smoke gray ground color patterned with dark brown to black stripes and marginal border; plastron unpatterned — straw to sulfur yellow or cream but may darken in old adults particularly males; head and neck grayish olive to gray; a cream colored stripe beginning at the snout runs above the eye and tympanum; mandibles and chin light olive yellow to cream but again may darken in old individuals; iris brown to smoke gray.

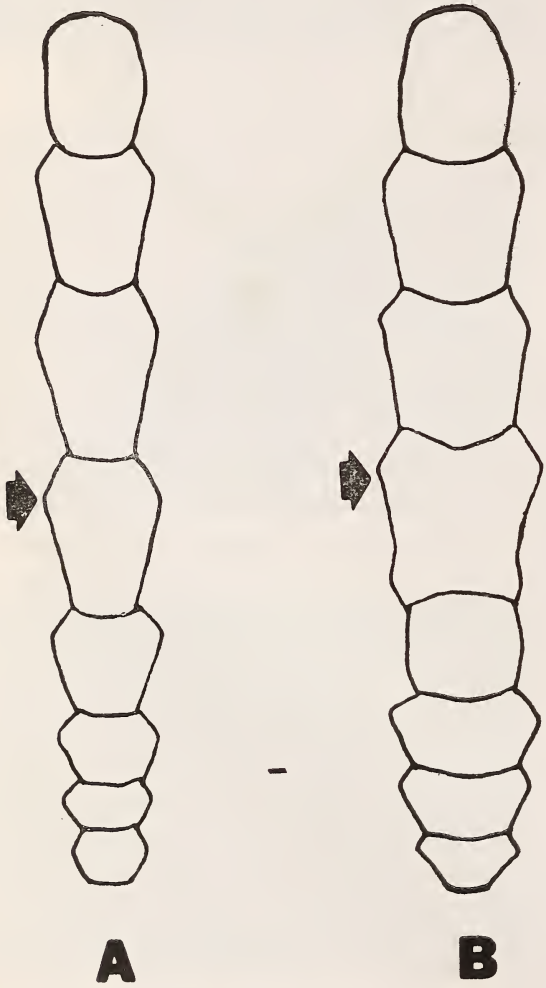


Fig. 3. Neural bones of *Kachuga dhongoka* (A) and *K. tentoria* (B). Arrow indicates the fourth neural which is hexagonal in A but octagonal in B.

Head moderate in size with somewhat upturned snout projecting beyond jaw; skin smooth anteriorly dividing into small irregular scales at rear of head; apex of upper jaw with shallow notch flanked on each side by small tooth-like projections; triturating surface broad, bearing single denticulated ridge; hyoid (immature female) with cartilaginous body and two pairs of ossified, single element horns.

Shell oval flaring posteriorly being widest across rear of Vertebral 4; a median keel usually evident anteriorly with a pronounced knob on Vertebral 2 and a lesser one on 3; Vertebrals 1, 3 and 4 usually longer than wide while 2, and 5 tend to be as wide or wider than long; seam contact formula: 1M 4> 6> 8M 10>; plastron narrow, truncated anteriorly and notched posteriorly; plastral formula: Ab > F > H >< P > A >< G; bridge broad exceeding length of both anterior and posterior lobes of the plastron; cloacal bursae present.

Size and Sexual Dimorphism: The sexes differ greatly in size. Seventeen shells collected along the Ganges River at Rajamahal and Kahalgaon were divided into male and female types (maturity not known). Average CL of nine "males" was 18.7 (range 15.9 to 21.3) cm while eight "females" averaged 36.6 (range 33.9 to 40.9) cm. The largest male and female examined in West Bengal markets measured 19.8 and 48 cm CL respectively. Chaudhuri (1912) and Das (1986) reported that males do not exceed ten inches and 25.5 cm CL respectively. Seven mature females collected by Rao and Singh (1985) from the Chambal River in Madhya Pradesh averaged 44 cm CL (range 39.2-48.0).

Dimensions of two typical individuals are: Female: 42.2 CL 31.2 CW 38.9 PL 16.3 H.

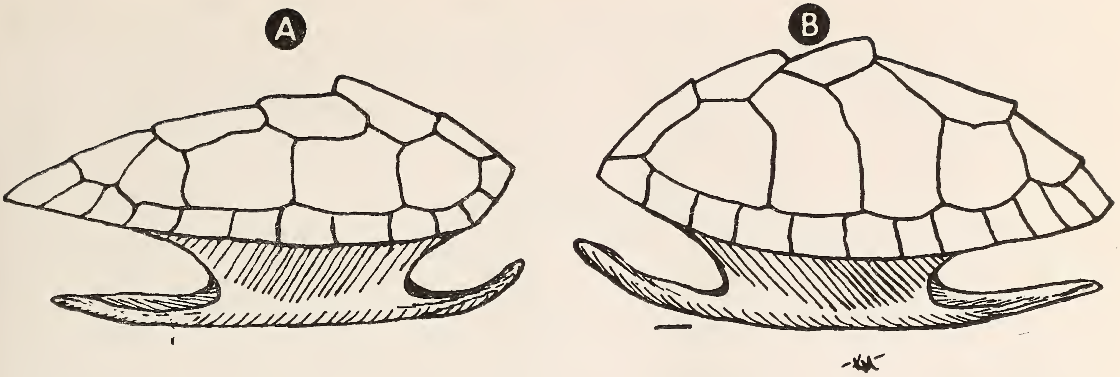


Fig. 4. Shells of *Kachuga dhongoka* (A) and *K. tentoria* (B). Note that the apex of A is at the second vertebral and that of B is at the third vertebral.

Weight 8.25 kg. Male: 19.1 CL 13.3 CW 16.2 PL 7.3 H. Weight 0.85 kg.

In addition to size, males can be distinguished from females by a longer tail in which the cloaca extends beyond the edge of the shell and by the presence of costo-peripheral (usually four prominant and one or two tiny) fontanelles in the carapace (Fig. 6).

Hatchlings: Eight hatchlings from four clutches obtained at the Chambal River in Madhya Pradesh had mean dimensions of 5.15 CL 4.41 CW 4.74 PL 2.47 H and mean weight of 24.25 g. Shells of hatchlings are weakly serrated posteriorly (Marginals 7-12). The central keel is broken and modified into two prominant, knobby spines on Vertebrals 2 and 3 and a smaller one on Vertebral 4. Vague lateral keels are represented by a line of tiny tubercles, one each on the areolae of Pleurals 1-4. A pair of keels run along either side of the plastron. Vertebral 2 is not pointed as in adults nor is Vertebral 4 particularly elongate. These characteristics develop with age.

Hatchling coloration is similar to that of adults. The central stripe is usually broken and is most pronounced on Vertebrals 2 and 3. The lateral stripes are less obvious consisting of a broken line of dashes or spots along the pleural scutes. Another series of dark blotches or dashes usually border the edge of the shell. The underside of the marginals may also be marked with dark pigment but the plastron is unpatterned. Smith's (1931) report of reddish brown patches on the plastral scutes of juveniles was likely an iron-based stain that commonly forms on the shell when turtles burrow in certain substrates. A cream to tan stripe beginning on the snout and running over the eye and tympanum is usually evident.

Natural History: The three-striped roofed terrapin inhabits moderate to large rivers. It appears highly aquatic, leaving the water only to bask and for nesting. Like certain other large riverine species (e.g. *Dermatemys, Callagur*), adults have considerable difficulty or are unable to right themselves once placed on their backs. The turtle is not aggressive and attempts to bite only after some provocation.

K. dhongoka were regularly seen basking on logs, debris, and sand banks during our survey of the National Chambal River Sanctuary, March 31-April 6. However, few were seen basking on an earlier trip during the

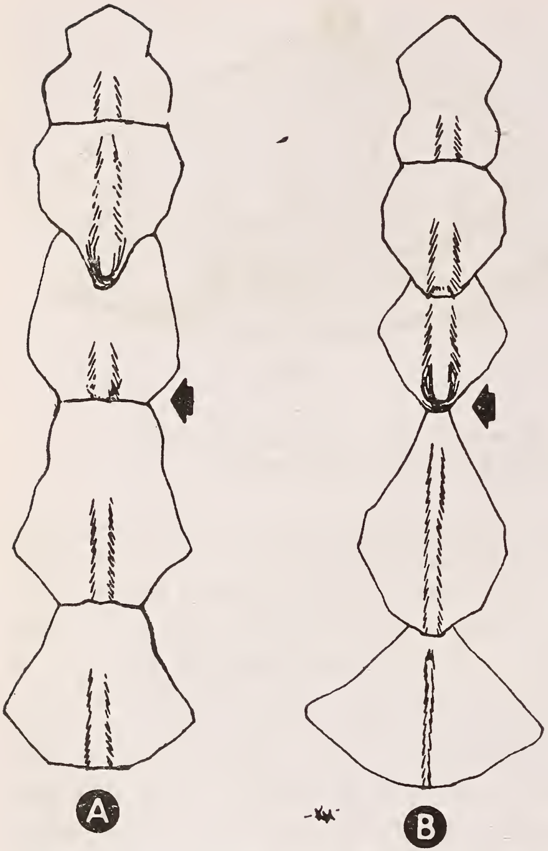


Fig. 5. Vertebral scutes of *Kachuga dhongoka* (A) and *K. tentoria* (B). Arrow denotes broad contact between the third and fourth vertebrals in A but narrow contact in B.

cold season (January 18-29). On this trip two females were captured by fishermen by dragging large hooks over the bottom in deep water (*c.* 10 m) of the nearby Yamuna River suggesting that some members of the population may have been dormant.

Anderson (1876) reported the species to be herbivorous based on his observations of two captives. Males, however, are omnivorous. Feces of a male (19.8 cm CL) purchased in a West Bengal market were full of bivalve mollusc shells while the digestive tract of another (19.1 cm CL) contained stems and leaves of aquatic plants and a trace of mollusc shells. No female feces were examined.

Nests of *K. dhongoka* were observed only in March and April at the National Chambal Sanctuary. However, two females reaching the Howrah markets on December 3 were gravid as was one of the aforementioned dormant(?) females collected on 27 January. Rao and Singh (1985) have confirmed that March and April are the peak nesting months in the Sanctuary but they also have found one gravid female as early as 17 December. This suggests the possibility that females may carry shelled eggs for a long period (including a period of dormancy) prior to nesting. The latest evidence of nesting was from the ovaries of a butchered female (38 cm CL) in a market in Belacoba, West Bengal which contained 18 fresh corpora lutea on 28 April.

Nesting takes place on sand banks near the river. Sixty two nests were found from 1 to 100 m (mean 14 m) inland from the river. Five which were excavated had an average depth to the first egg of 21.5 (18 to 27) cm and to the bottom of the nest of 31 (25-35) cm. The nests contained from 21 to 34 (mean 26.2) eggs. Rao and Singh found an average and mode of 23.5 and 25 (16-35) eggs per clutch at this locality in 65 nests examined from 1983 and 1985. Based on 161 eggs from 7 clutches, egg length varies from 46 to 65 (mean 57.3, SD 4.8) mm, egg width from 32 to 39 (mean 35.9, SD 1.5) mm and weight 30 to 55 (mean 43.7, SD 6.1) g. Egg shells vary from flexible to brittle even within a clutch. Usually the shell can be indented with moderate thumb pressure but this often results in localized fracturing of the mineral layer.

Little is known concerning the reproductive effort of individual females. One (42.6 cm CL and 6.65 kg) from the Yamuna River

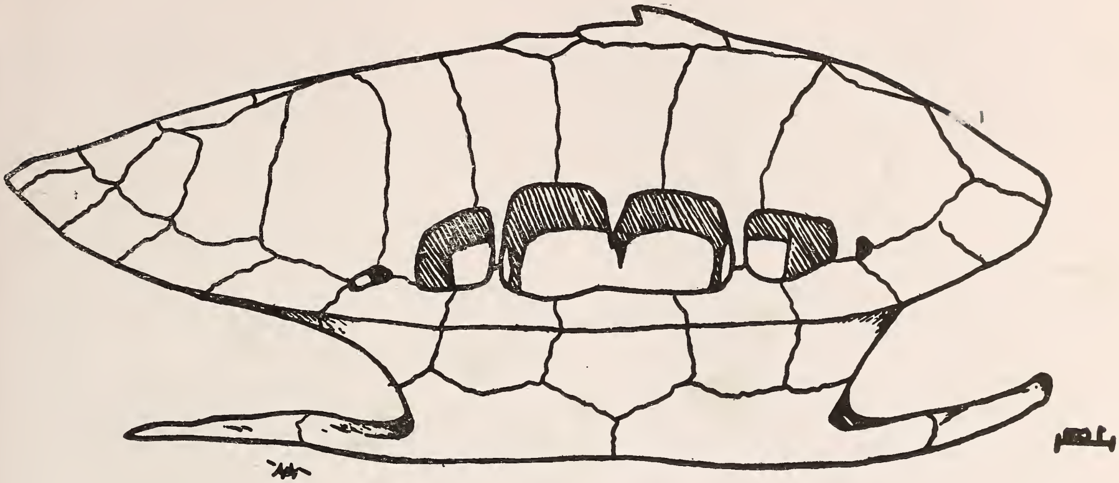


Fig. 6. Shell of a *Kachuga drongoka* male with scutes removed to show large costo-periferal fontanelles.

contained 26 eggs with a RCM of 0.128. The ELI, EWI and EMI were 11.3, 7.9, and 0.498 respectively. Rao and Singh (1985) provided data for two others. One (415 cm and 7.86 kg) with 18 eggs had an RCM of 0.097 and ELI, EWI, and EMI of 14.4, 8.1, and 0.59. The other 40.5 cm CL (no weight given) contained 21 eggs having an ELI of 15 and an EWI of 9.5.

Three eggs incubated in a plastic refrigerator box on moist cotton at ambient temperatures ranging from 28 to 35 degrees hatched in 53 to 55 days. The earliest date of nest emergence observed on the Chambal River was 29 April (Rao and Singh 1985).

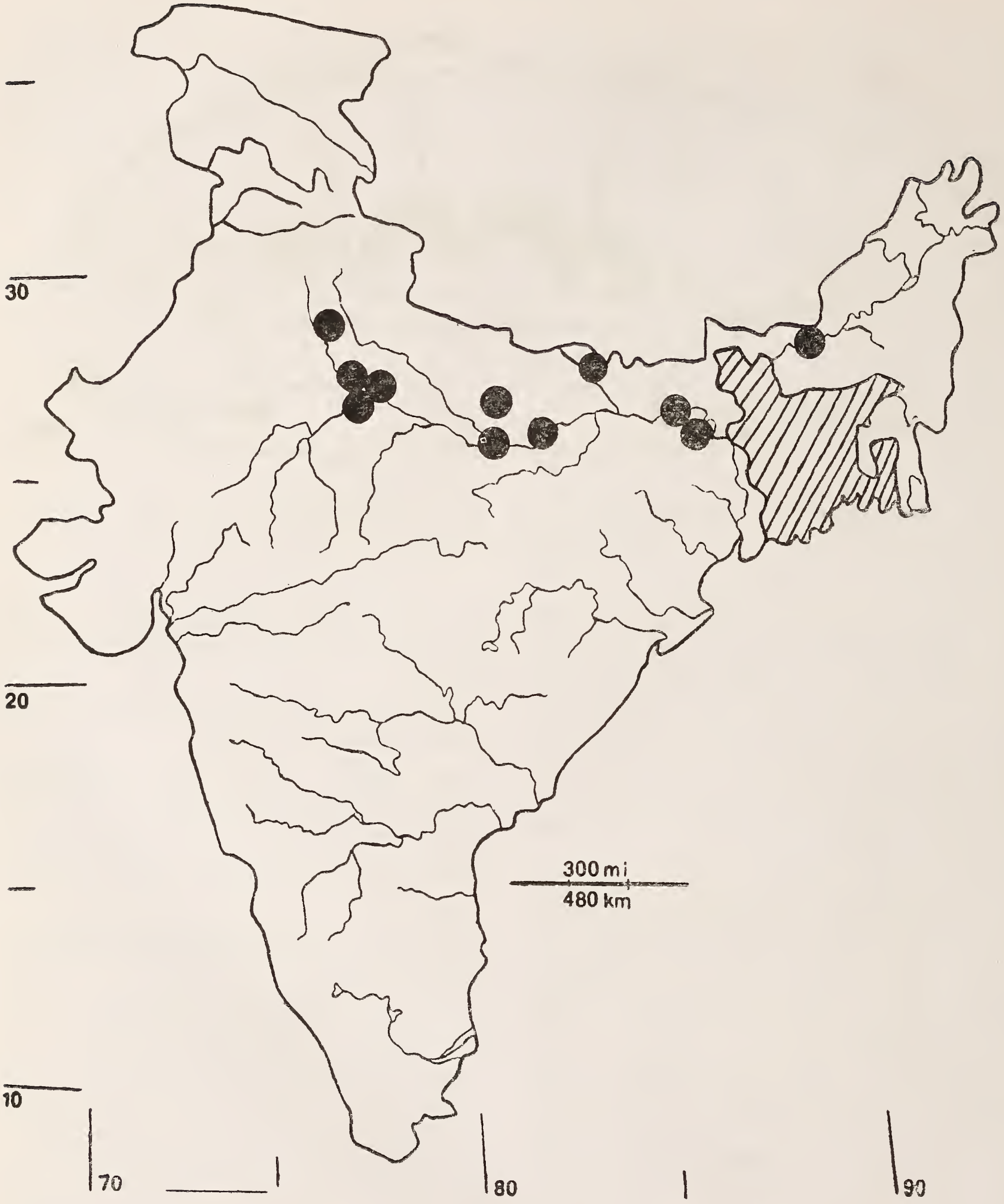
Distribution: The three-striped roofed terrapin occurs in the Ganges and Brahmaputra drainages of Nepal and India. Only a shell has been found in Bangladesh (Khan 1982) but considering the known distribution, its occurrence in this country is expected. Smith (1931) reported that the species occurred only as far westward as Allahabad on the Ganges but recent records indicate that it is distributed throughout most of this river's drainage (Fig. 7).

Specimens were collected from the following localities during the survey:

FMNH 224108 — Hindon River, Mohen Nagar, Ghaziabad, Meerut District, U.P.
BNHS 1343 — Yamuna River, nr. Etawah, Etawah District, U.P.
FMNH 224154 — Chambal River, Barenda, Morena District, M.P.
BNHS 1320 — Narayani River, Parsauni Farm, *c.* 40 km NW Bettiah, Bettiah (W. Champaran) District, Bihar.
EOM 2751 — Ganges River, Kahalgaon, *c.* 50 km W. Sahibganj, Bhagalpur District, Bihar.
EOM 2730 — Ganges River, Rajmahal, Dumka (Santhal Parghana) District, Bihar.
FMNH 224136 — Market at Belecoba, Jalpaiguri District, West Bengal. (Said to be from Bihar).

In addition, I have examined preserved specimens from the following localities and judge them valid.

ZSI 194+197 — Yamuna River, Agra, Agra District, U.P.
Yadava (1980) — Saryu River, Ayodhya, Faizabad District, U.P.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300 mi
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Fig. 7. Distribution map of *Kachuga dhongoka* in India based on surveys of Indian rivers conducted from 1981 to 1983 and including museum records verified by the author.

BMNH 1878.8.18.12 — Ganges River, nr. Varanasi, Varanasi District, U.P.
ZSI 18319+20 — Brahmaputra River, Sonarpur, Kamrup District, Assam.

Kachuga kachuga (Gray 1831)

RED-CROWNED ROOFED TERRAPIN — Plate I, C-F

Identification: A large riverine *Kachuga* (to 56 cm CL) having two denticulated ridges on the palate, an unpatterned carapace, a second vertebral scute with a straight posterior margin and a pair of oval yellow, red or orange patches on throat.

Description: Sexual dichromatism pronounced. Males (FMNH 224128 and BNHS 1341): carapace — unpatterned, drab to brownish olive, a wash of red may be present along midline anteriorly; plastron — unpatterned, cream to light yellow; head and neck brightly patterned; ground color of head blueblack a broad geranium red patch extending from top of snout to occiput; neck creamy white dorsally with six bright parallel red stripes, four of which converge at posterior of head merging into red patch (most descriptions of this species in the literature state there are seven red stripes on the neck; this may be an error perpetuated from the early descriptions, at least this was not true of these males); two sulfur yellow stripes mark the side of the head — a post ocular running from the eye across the top of the tympanum and another beginning at the snout, crossing over the upper mandible and the lower edge of the tympanum onto the neck; iris and sclera of eye orange to orange yellow; lower mandible with a creamy white stripe along its lower border; throat creamy-white with an orange oval spot on each side; limbs brownish olive anteriorly with a wash of yellow. (Anderson 1878 reported red on the limbs but none was evident here.)

The bright male coloration appears somewhat seasonal. FMNH 224128 appeared as above when captured in January but after two months in captivity, the red stripes had darkened to a deep red (almost maroon), the whitish areas between the stripes had become gray and the orange tó orange-yellow eyes had become light yellow.

Females (FMNH 224152): dorsum unpatterned; coloration dark brown to black including carapace, head, eyes, neck, and anterior face of limbs; silvery to pale yellow mandibles in conspicuous contrast to the otherwise dark turtle; plastron pale yellow but under side of marginals marked with diffuse melanin. (Note: Another female obtained from the Calcutta markets differed from the above by having a poorly defined, light postocular stripe and considerable dark pigment on the plastral scutes.)

Head medium-sized with a slightly, upturned, somewhat projecting snout; skin of head smooth anteriorly dividing into irregularly shaped scales postero-laterally; jaws strongly serrated; upper, weakly bicuspid with shallow notch; lower with a single central tooth flanked by notches; palate broadly expanded, its triturating surface bearing two denticulated ridges (as in *Batagur*), the anterior being most prominant; lower jaw with pronounced coronoid process and triturating surface bearing single denticulated ridge (*Batagur* differs in having a low coronoid process and a second ridge at posterior edge of triturating surface).

Shell oval, widest across Vertebral 4 between the seventh marginals; a median keel with prominant knob on Vertebral 2 and lesser knobs on Vertebrals 3 - 5 becoming obscure in older individuals; seam contact formula: 1M 4> 6M 8M 11<; Vertebrals 2 and 4 usually longer than wide while Vertebrals 1, 3, and 5 are wider or as wide as long; plastron narrow, shallowly notched posteriorly and truncated anteriorly; plasral formula: Ab>

F> H> P> A> G; bridge width extensive exceeding length of either plastral lobe.

Anderson (1876) reported that the cloacal bursae are present but that their walls are smooth not lined with villi as in the *Pangshura.*

Size and Sexual Dimorphism: Measurements of four males and three females examined on the survey are as follows:

FMNH 224127 M(shell) — 25.2 CL 19.8 CW 23.7 PL
Living M — 26.5 CL 21.2 CW 24.2 PL 10.9 H
BNHS 1341 M — 27.9 CL 20.6 CW 24.5 PL 11.3 H 2.5 kg
FMNH 224128 M — 29.0 CL 22.1 CW 25.1 PL 10.9 H 3.1 kg
FMNH 224152 F — 47.8 CL 36.9 CW 45.6 PL 20.4 H 15.7 kg
Living F — 50.4 CL 38.3 CW 48.0 PL 20.2 H 18.6 kg
EOM 2841 F(shell) -- 52.0 CL 38.2 CW

Males differ from females by having brighter coloration, smaller size, four prominent costo-peripheral fontanelles in the shell and a relatively long tail in which the vent opens beyond the edge of the carapace.

Hatchlings and Immatures: A recently hatched individual (Pl. I-E) from a clutch obtained on the Chambal River in U.P. measured: 6.0 CL 5.0 CW 5.6 PL 2.9 H 36 g Wgt. The shell is strongly serrated posteriorly (more than in *K. dhongoka*). Sharp spines are present on the free edges of Marginals 5-7; spines on Marginals 8-12 are blunt but a deep notch just anterior to each gives the posterior of the carapace a ragged appearance. The mid-dorsal keel is modified into blunt spines on Vertebrals 2 and 3 and a small sharp spine on 4. Lateral keels are indicated by a weak ridge over the pleurals. On the plastron two parallel ridges running along either side from humeral to anal scute are decked with a small sharp spine at the posterior of each scute.

The shell is light grayish-olive above with a pale yellow band along the periphery of Marginals 4-12. The plastron is pale yellow and unpatterned. The head is olive brown with a broad, light cinnamon stripe extending posteriorly from the eye over the tympanum and onto the neck; immediately beneath a wide plumbeous to dark neutral-gray stripe runs from beneath the eye and the angle of the mandibles over the lower part of the tympanum to the neck. Within this dark stripe a narrow light neutral-gray runs from beneath the eye to the tympanum. Six faint stripes of light cinnamon outlined in black are discernible on the neck. The throat is pearl gray decked with dark oval patches on either side instead of bright orange as in adults.

An immature specimen (20.5 CL 16.0 CW 18.9 PL 8.8 H and 1.24 kg) from Bateshwar, U.P. (Pl. I-F) is briefly described herein to provide additional information on ontogenetic change in coloration. The carapace is olive gray to drab with central keel paler in color. The cream colored plastron is unpatterned. The head is olive-gray with a broad creamy band running along dorso-lateral portion from top half of eye over tympanum to neck. Below a medium neutral-gray band runs from lower portion of eye posteriorly over tympanum onto the neck. The neck, also medium neutral-gray, is decked by six somewhat darker gray stripes. The iris is amber. The mandibles are light orange-yellow near the tomium and olive-gray elsewhere. The limbs are olive-gray anteriorly and creamy white posteriorly.

Natural History: Little has been published concerning the habits of this species and what information is available must be viewed with caution as the turtle may be easily confused with *Batagur.*

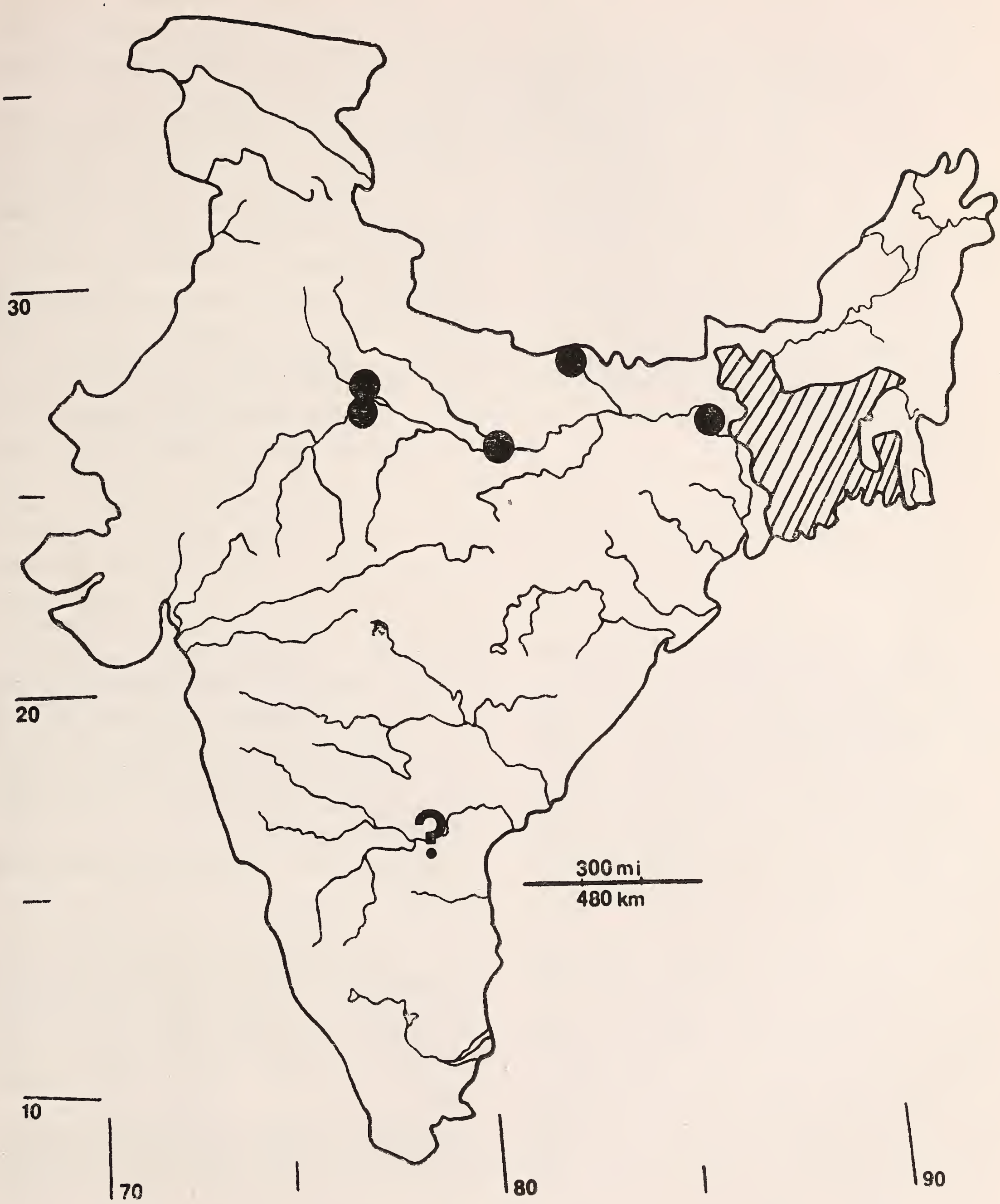
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Fig. 8. Distribution map of *Kachuga kachuga* in India. (See legend of Fig. 7).

Red-crowned roofed terrapins were found in moderate to large rivers (Chambal, Yamuna, Gandak). When in the water their heads can be recognized at a distance by their bright yellow to silvery mandibles. We observed both sexes basking on rocks, logs and debris on the Chambal and Yumuna Rivers in late March and early April. All three females observed basking were near deep pools but a single male was on a rock not too far from shore. They were very wary and could not be approached. On an earlier trip to the same area during the cold season (January 18-29), no basking was observed by this species even though large numbers of the smaller *K. tentoria* basked every day.

Fresh nests were located on the Chambal River, 12 km south of Bah in the Agra District of U.P., April 2-4. Average measurements of 18 eggs selected randomly from three nests containing 20, 25 and 25 eggs were: length 71.6 (64-75) mm, width 40.3 (38-45.5) mm and weight 51.8 (45.5-67.5) g. The nests were 8 to 31 m from the water and from 42 to 54 cm deep. Between 1983 and 1985 Rao and Singh (1985) examined 11 clutches ranging from 11 to 30 (mean 18, mode 18) eggs in the National Chambal Sanctuary. Although the primary nesting season is March and April in this region, they found one female (53 m CL and 22 kg) carrying 18 eggs on 17 December 1984.

Based on data provided by Rao and Singh, the mean egg size for the above female was 64.5 x 39.9 mm and 55.3 g allowing a calculation of the reproductive effort as: RCM — 0.046, ELI — 11.5, EWI — 7.12, EMI — 0.25. Another female (49 cm CL, no wgt. given) with an average egg size of 66.5 x 37.6 mm would have an ELI — 13.5 and an EWI — 7.6.

Food habits were not observed in the wild but two females and two males kept in captivity readily ate leafy vegetables and fruits. One male gorged itself on casuarina leaflets which dropped into its tank from over hanging trees.

Distribution: The red-crowned roof terrapin definitely occurs in the Ganges drainage of India and Nepal (Fig. 8). Other records must be viewed with caution. The considerable degree of ontogenetic variation, moderate sexual dimorphism and extreme sexual dichromatism have caused frequent misidentification of this species. For example I have found specimens confused with *K. dhongoka, K. smithii* and *Batagur baska* at the Zoological Survey of India. Therefore the occurrence of *K. kachuga* in Burma (Gunther 1864, Theobald 1868) and the Krishna (Gray 1862) and Godaveri (Anderson 1878) drainages of India need verification. Our survey of the lower Godaveri found no evidence of large *Kachuga.* I have examined the type of *Batagur ellioti* (BMNH 55.12.17.15) reputed to be from the Krishna River. The specimen is definitely a young *K. kachuga* but the locality is questionable. The actual specimen is without data but Gray (1862) felt that it looked so similar to a specimen from the Kistna (Krishna) River drawn by Walter Elliot that he assumed this to be the type locality.

Specimens were collected at the following localities:

FMNH 224128 — Chambal River, Barenda, 10 km W Pinahat, Morena District, M.P.

FMNH 224152 — Yamuna River, Bateshwar, 13 km N Bah, Agra District, U.P.

EOM 2841 — Bherihari Colony Village, 10 km S Valmiki Nagar (Nepal Border), Bettiah District, Bihar.

In addition the following preserved specimens have been examined and the identifications verified.

ZSI 501 and 502 — Allahabad, Allahabad District, U.P.

ZSI 20632 to 20634 — Ganges River, Rajmahal, Dumka (Santhal Pargana) Distrcit, Bihar.

(*to be continued*)

BASIC DIURNAL ACTIVITY PATTERN OF BLACKBUCK, *ANTILOPE CERVICAPRA* LINN. OF BALLAVPUR WILDLIFE SANCTUARY, W. B. AND ITS SEASONAL VARIATION[1]

Bratindranath Chattopadhyay[2] and
Tanmay Bhattacharya[3]

(*With four text-figures*)

The diurnal activity pattern of Blackbuck *Antilope cervicapra* Linn. was studied in the Ballavpur wildlife sanctuary for a year. Existence of a basic activity pattern has been established with both diurnal and seasonal variation in relation to sex and age class of the individuals. Pasture and climatic conditions appear to be the major factors influencing the pattern.

INTRODUCTION

Ballavpur wildlife sanctuary, a man made forest, holds a small and manageable population of blackbuck *Antilope cervicapra* Linn. (Bhattacharya & Chattopadhyay 1979). Attempts are being made to identify various aspects of the ecology and behaviour of the antelope in the sanctuary during the past few years. The present paper is a part of the investigation and deals with the major activities of the antelope within the diurnal and seasonal time-frame. Only stray informations in this regard are available through the works of Schaller (1967), Nair (1977), Krishnan (1972), and Roberts (1977).

METHOD OF STUDY

The activity patterns of the blackbuck were broadly classified following Jarman and Jarman (1973) into 4 categories namely, grazing, walking, standing/scanning and lying. In this study, activity refers to any action which resulted into a change in the position of the creature in relation to space. An animal was considered static while standing or scanning and while lying down, otherwise it was considered mobile. Main mobile activities were grazing and walking. Walking in this account refers to the movement resulting into change in location and includes running, trotting etc. Stand/scan activity was qualified as the animals observed standing idly with occasional scanning. Scanning refers to searching, looking for or at object in a standing posture. Only these major activities were studied for establishing the daily activity pattern and its seasonal variations. Various other activities like, urination, defecation, display of different

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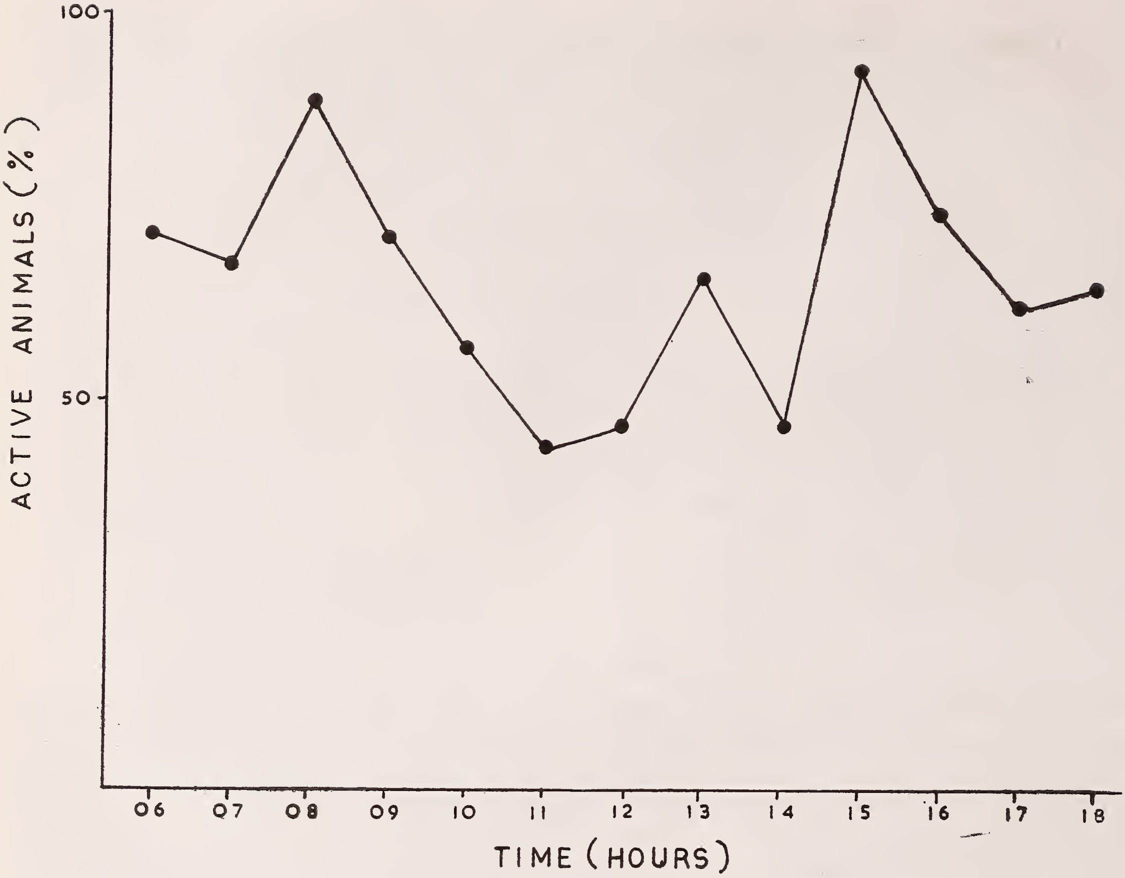


Fig. 1. Total Activity of Blackbuck between 06.00 and 18.00 hours.

behaviours etc., that are spaced within these major activities were not taken into consideration.

Routine observations were made by walking along the laid gridlines. Whenever a group or individual animal came into the sight the observational informations were recorded in the data sheets. A safe distance of about 75-100 metre was found to be adequate for observing the animals. Observations were made using a 7×35 binoculars.

A pilot survey was conducted during May to July 1977. This was followed by a systematic regular observation schedule between September 1977 to August 1978. The daily observation schedule was divided into three shifts; morning shift: 06.00-10.00 hr. noon shift: 10.00-14.00 hr and afternoon shift: 14.00-18.00 hr. Once in a month a continuous 12 hourly observation schedule (06.00 to 18.00 hr.) was undertaken. The total time spent in the sanctuary during this study was 660.30 hr. The hour-wise analysis of the activities during the day time (from 06.00 hr to 18.00 hr) is represented here as the mean of the percentage of the total number of animals observed

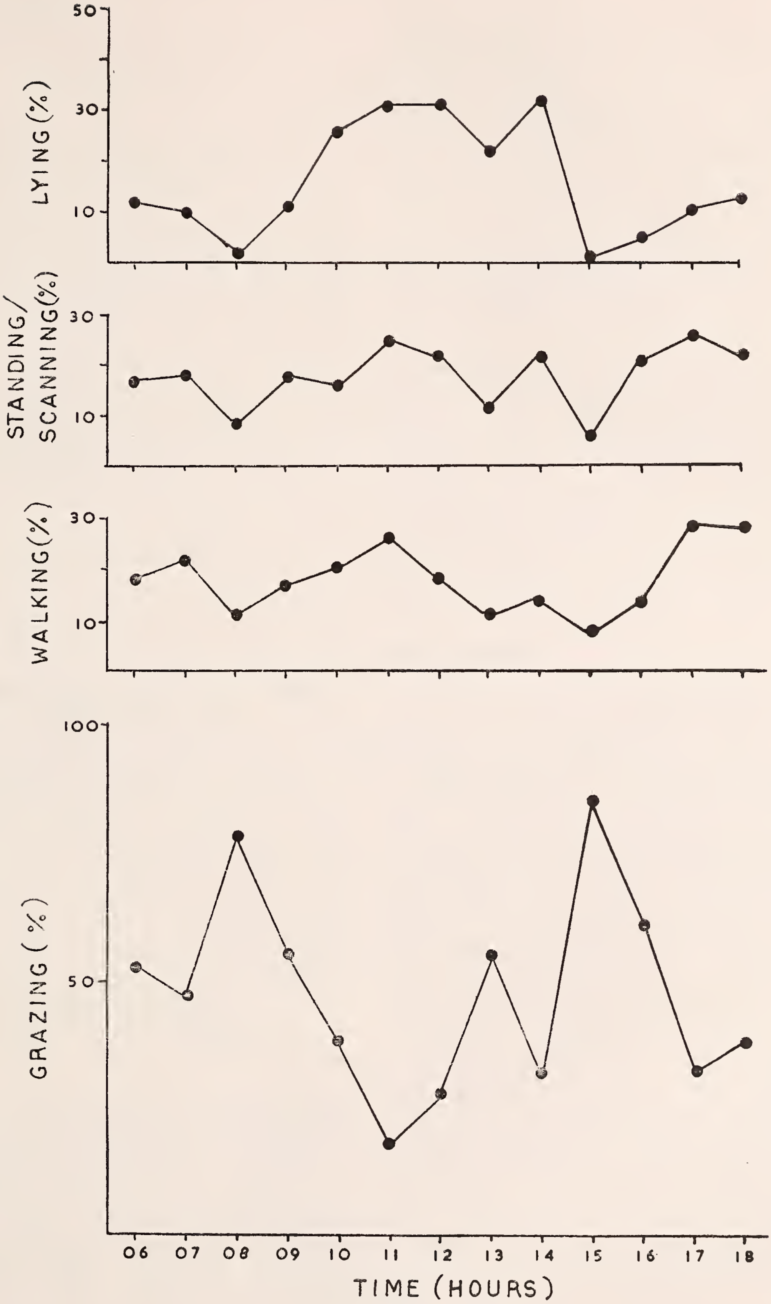


Fig. 2. Activity: Hourwise analysis.

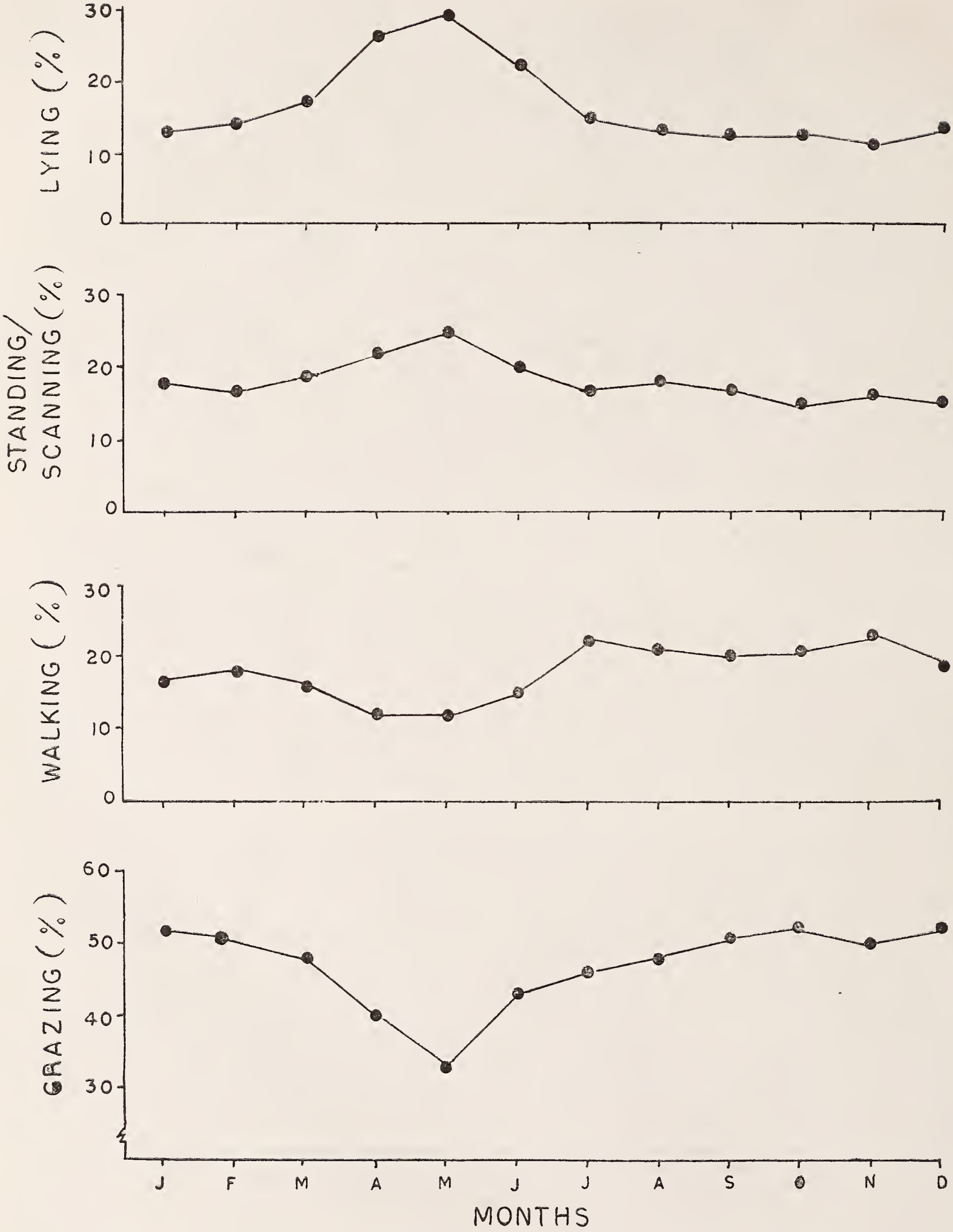


Fig. 3. Activity Budget: Monthwise analysis.

during the different hours of the day, during the entire study period.

RESULTS

Daily activity pattern

The total daily activity cycle of the blackbuck is shown in fig. 1. The animal mostly remained active in the day time except a brief spell around noon when less than 50% of the population were seen to be active. The activities reach their peaks once in morning, at 08.00 hr. and again during afternoon, at 15.00 hr. when about 90% of the animals were active. These two peaks tally with the time of the supply of supplementary food. After 08.00 hr. the total activity declined through noon except for a brief rise at 13.00 hr.

An analysis of the various major activities (Fig. 2) revealed that grazing followed the general pattern of daily activity, peak period of grazing corresponding with the decline in walking, standing/scanning or lying. On the other hand hours of low grazing were compensated by walking, standing/scanning or lying. During peak hours of grazing no individual was seen lying, whereas, during low period of activity and grazing, many were seen lying down. None the less only less than 35% of the population was seen at any time to be involved either in lying or in standing/scanning taken separately (Fig. 2).

Annual pattern

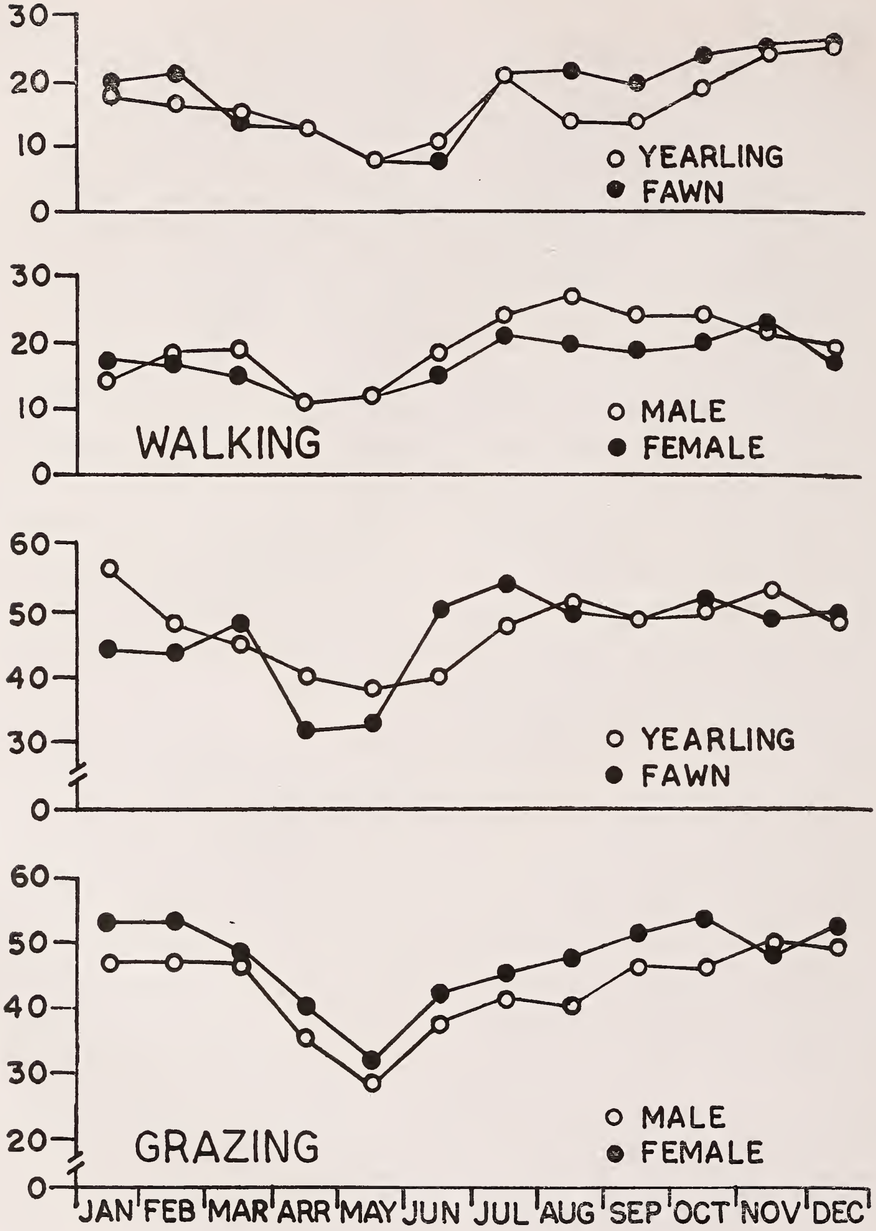
The monthly variation and annual pattern of different activities are shown in figure 3. As far as grazing is concerned, it was found to be quite common between September to February, when at least 50% of the total population were seen to be engaged in doing so. From March onwards a decline in grazing was seen till May when only 38.4% of blackbuck were seen grazing. With the onset of rains in June again a rise in the grazing activity was observed. Turning to walking (including running) it may be observed that between July to November more than 20% of the individuals were seen walking. Maximum degree of walking was observed in November (23.1%). On the other hand between December to June less than 20% of the individuals were seen walking. The lowest frequency was encountered in May (11.7%).

Standing, scanning and lying, as static activities, characteristically show just the reverse relation with grazing and walking in annual pattern. These activities were at their peaks in May. Lying was more common compared to standing/scanning. However, in either case only less than 25% of individuals were engaged in such activities except in April and May in case of lying and only April in case of standing/scanning.

Monthly variation in the activity pattern in relation to sex and age

Although grazing was less frequent in males than the females yet both the sexes followed a more or less similar pattern all round the year with lowest frequency encountered during May (Fig. 4). On the contrary, although both males and females followed same trend as far as walking is concerned it was more frequent in males. Monthwise variation in the frequency of grazing activity of yearling show two distinct phases: a more or less steady high level from July to February and a declining phase between March to June when grazing is less frequent. Fawns on the other hand show a low frequency of grazing during summer months (April and May) which increased with the onset of rains and maintained a more or less high value thereafter.

Similarly both fawns and yearlings had


30
20
10
0
○ YEARLING
● FAWN
30
20
10
0
WALKING
○ MALE
● FEMALE
60
50
40
30
0
○ YEARLING
● FAWN
60
50
40
30
20
0
GRAZING
○ MALE
● FEMALE
JAN
FEB
MAR
ARR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC

Contd.

Fig. 4.

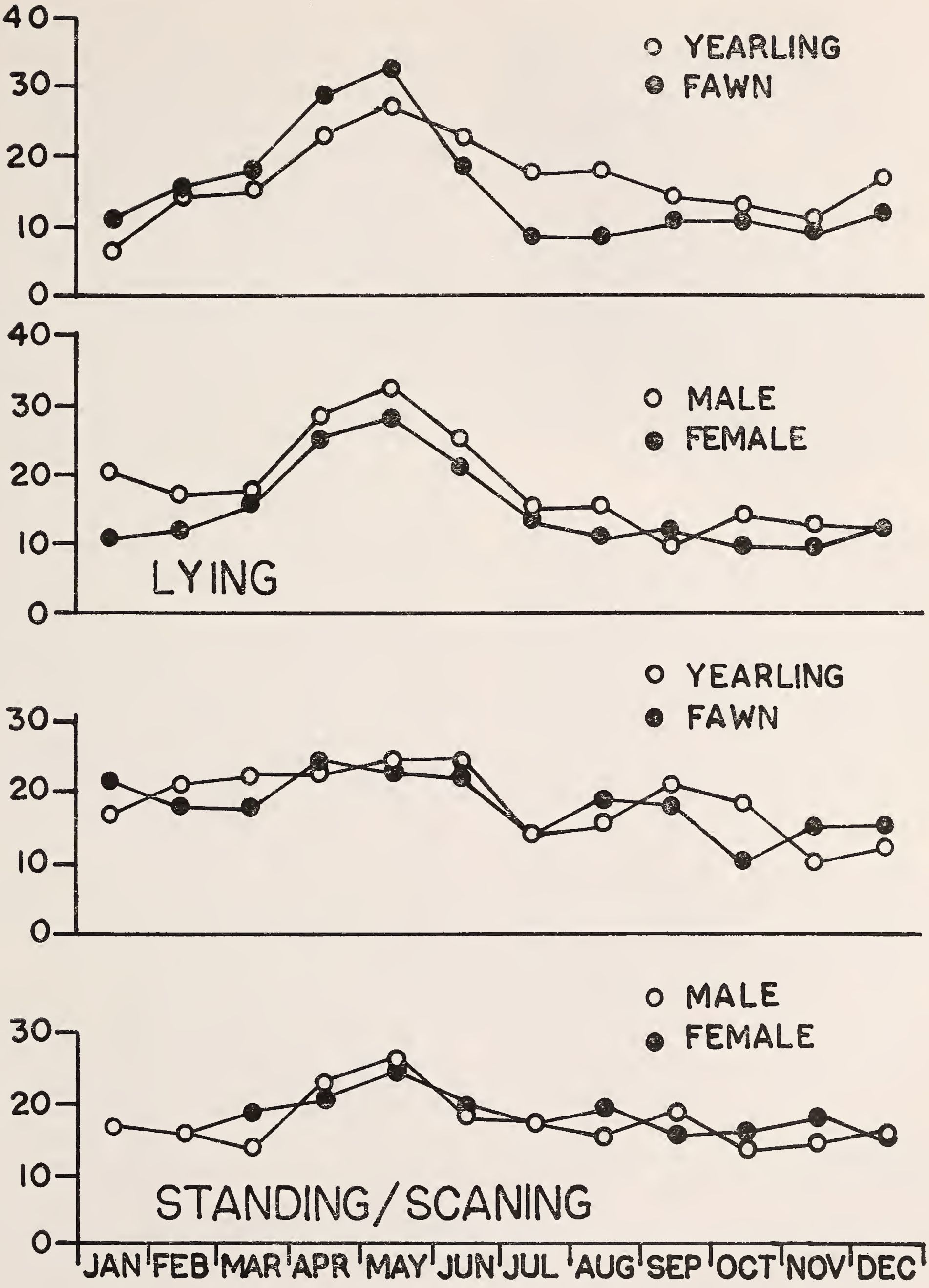


Fig. 4. Monthly variation in activity pattern in relation to sex and age class.

identical annual activity pattern as far as walking is concerned which was at low key between May and June. Likewise standing/scanning, also followed a more or less similar trend with relatively high value during April and May, in males and females and during June, in fawns and yearlings.

Lying, which was more common among males than in females, followed the same annual pattern in both the sexes with high frequency during May. Fawns and yearlings also had a peak value during May. Fawns spent more time in lying between January and May in comparison to yearlings but the pattern was reversed during rest of the year.

DISCUSSION

In the diurnal activity pattern grazing and walking showed alternative bouts with proportional intensities. Whenever the frequency of grazing for a particular hour dropped, that of walking increased suggesting a good coordination among those two activities where walking is a function of grazing or vice versa. This functional relationship reflected the mobile-grazer character of the species. Such mobile-grazer character of this species in open land has also been reported by Prater (1965), Schaller (1967) and Roberts (1977). However, in the monsoon and post-monsoon months, with the new flush of green vegetation the animals required little walking while grazing upon thick and continuous carpet of grass. Different social interactions reached their peaks by that time, resulting in high frequency of walking during that period. Nair (1977) also observed that during rutting more time is spent in walking and displaying than in grazing by the males.

The number of antelopes observed lying and standing/scanning were high throughout the summer and early monsoon, the common functions of these two types of activities were occasional rumination besides watching, taking rest or sleeping while in lying posture. The standing/scanning and lying activities drop remarkably from monsoon to winter and perhaps the high value of these activities in summer was due to the thermal reaction of the animals and its occupation with rumination. Balch (1955) has referred that ruminants rarely sleep because of the need to keep the thorax upright while ruminating. However, the rumination will also take longer time during summer due to the high content of fibers, in the available food. Morag (1967) has suggested that in sheep, rumination replaces sleep, when they are fed with high fiber containing food. In blackbuck the inactive portion of the small intestine is relatively larger and the reticulum of the stomach is comparatively inefficient. To overcome these inefficiencies a fine grinding of food is required (Gill & Korda 1960). The situation changes with the new flush of ground vegetation after rain.

The dominance of the grazing activity throughout the daytime is also reported by Schaller (1967), Krishnan (1972) and Roberts (1977). Perhaps the extensive feeding of this mobile-grazer species during daytime is facilitated by the day light in selecting grass and keeping it alert against predators.

Thus it seems that there is a definite pattern as far as the major activities are concerned in the fixed hours of the day which are subjected to seasonal variations. Other activities i.e. urinating, defecating, displaying etc. are jected to seasonal variations. Other activities, discussed here. The availability of pasture and atmospheric temperature seem to be the most strong ecological determinants in the seasonal variation of the basic type. Grazing and walking almost exactly correspond with the seasonal variation in pasture quality. However, with the declined pasture quality an increase in walking activity may be expected but the high temperature in summer acts as a limiting factor for mobile activities. Similar observations have been made by Krishnan (1972).

The entire diurnal activity pattern can be divided into two distinct phases, one corresponding with low sun elevation i.e. morning and afternoon and the other with high sun elevation, i.e. from late morning to late noon. This arbitrary classification, however, excludes 08.00 hr and 15.00 hr activities as these are conditioned with the supply of food at the feeding stations. Along with the seasonal pasture quality and atmospheric temperature, the sun elevation in day time also acts as an important factor. This is explained by the high mobile activities during morning and afternoon hours and diminishing late morning to late noon activities.

The activity pattern of ungulates may also be influenced by the sex and the age of the animals (Jarman & Jarman 1973, Leuthold 1977, Sharatchandra & Gadgil 1980). Fawns are more sensitive to extremes of temperature than yearlings. As far as the grazing is concerned, the new flush of green influences higher mobile activity of the fawns relatively more than those of other members. Throughout the mid winter and summer the fawns spend much time in lying down. Social interactions have a remarkable effect on the increased mobility of the males and relatively decreased mobility of the yearlings. As in the present investigation it was also reported by Schaller (1967) and Nair (1977) that in blackbuck grazing is more frequent in females than in males. On the other hand lying was more frequent in males than in females as observed by Schaller (1967).

ACKNOWLEDGEMENTS

We sincerely acknowledge the help rendered by Directorate of Forests, Govt. of West Bengal and Staff of the local Forest Beat Office. Thanks are also due to Head of the Department of Zoology, Visva-Bharati, for providing facilities and to the President, Forest Research Institute and Colleges, Dehra Dun, for providing a Junior Research Fellowship to one of the authors (B.C.).

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ICHTHYOFAUNA OF BIJNOR DISTRICT (UTTAR PRADESH)[1]

M. K. SHARMA AND D. B. RAJPUT[2]

(*With a text-figure*)

INTRODUCTION

Bijnor district, Uttar Pradesh has its own zoogeographical significance. In spite of the richness of its varied fauna no attempt has so far been made to explore them. With this point in view faunal studies of fishes covering Bijnor were taken up.

Stray references in faunal studies covering much wider areas, such as those of Hamilton (1822) and Day (1878) are the only sources of information. A few references are available on the fish fauna from adjoining areas namely collections from Eastern Doons, Hora & Mukerjee (1958), Lal & Chatterjee (1962), Sinha and Shiromny (1953) from Meerut, Majumdar (1958) from Delhi State and Mahajan (1963) from Muzaffarnagar.

MATERIALS AND METHODS

The fishes were obtained from Commercial catches. Cast net was most commonly used although sweeping, towing and bag nets were also frequently employed. Daily visits to the Bijnor, Najibabad, Afzalgarh, Dhampur, Sherkot and Chandpur fish markets were made during three years and collections were made of fishes not commercially exploited. Representative specimens of each species were brought to the laboratory and their taxonomy studied either on fresh or preserved specimens.

TOPOGRAPHY

Bijnor district is situated towards the east of river Ganges between Muzaffarnagar and Saharanpur districts in the west, Nainital in the east; Pauri-Garhwal to the north and in the south Moradabad. (Fig. 1). It is roughly pentagonal in shape with an altitude varying from 238 to 593.44 metres above sea level and located between 29° and 30°N and 78° to 79°E. Its length from north to south is about 99.2 km. and width from east to west 89 km, covering an area of about 4833 square km. The region is mostly cold for six months or moderately cold. In other months it is hot but never excessively so. The average temperature during winter varies from 7.5°C minimum to 30°C maximum and during summer it is 23.8° to 39°C maximum. The average rainfall varies from 85 to 121 cm in different parts of the district. There is a considerable slope from north to south. The main rivers descend into the plains from the Himalayas, which accounts for the number of hillstream fishes recorded in the Table 1.

FISHERY RESOURCES

The district has rich fishery resources. Besides the two large rivers, the Ganges and Ramganga, there are seven smaller ones which

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[1] Accepted February 1982.

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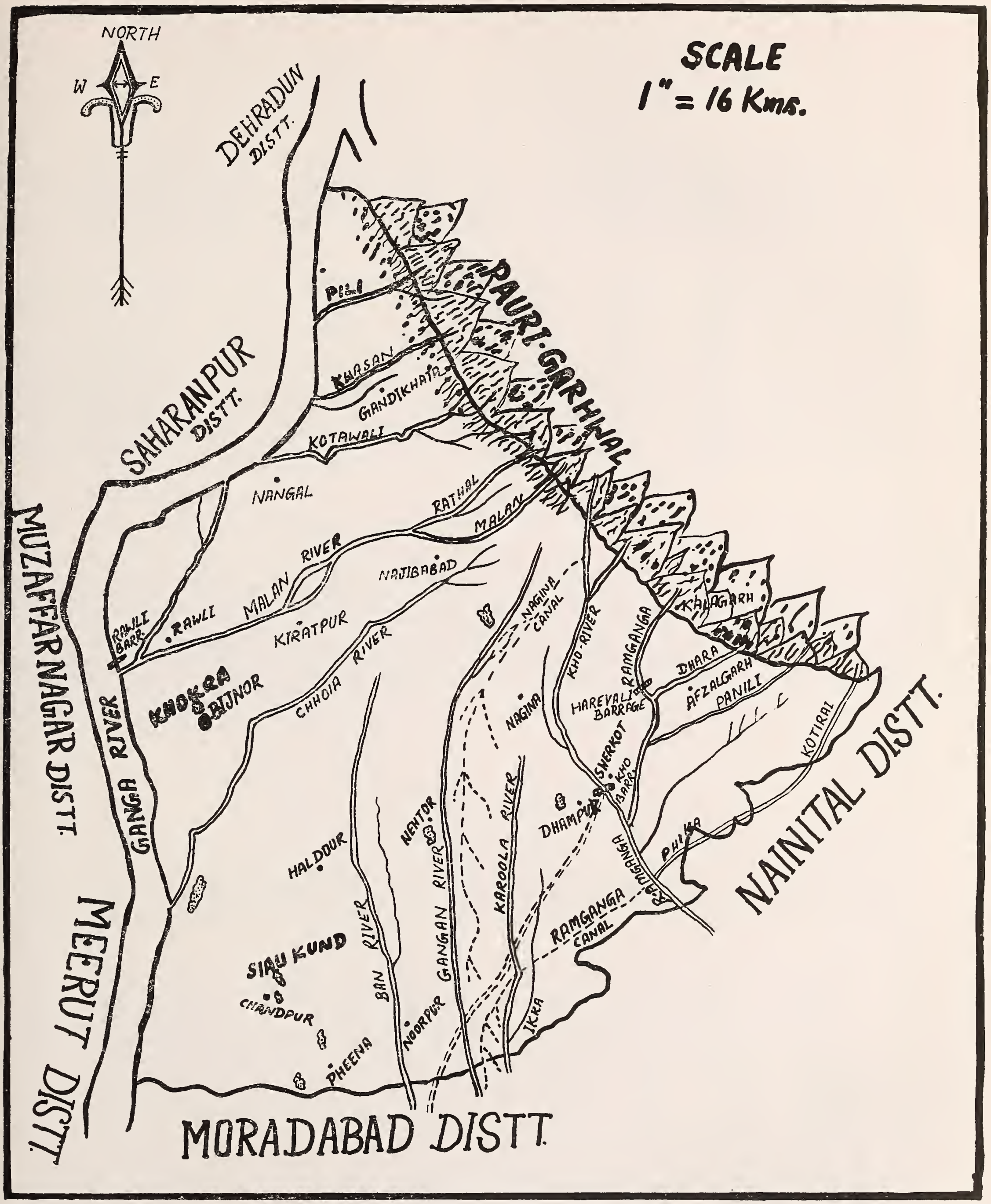
NORTH
W
E
SCALE
1" = 16 Kms.
DEHRADUN DISTT.
SAHARANPUR DISTT.
MUZAFFARNAGAR DISTT.
MEERUT DISTT.
MORADABAD DISTT.
NAINITAL DISTT.
PAURI GARHWAL
PILI
KHASAN
GANDIKHATA
KOTAWALI
NANGAL
RATHAL
MALAN
MALAN RIVER
NAJIBABAD
RAWLI BARR.
RAWLI
KIRATPUR
KHOKRA
BIJNOR
GANGA RIVER
CHHOIA RIVER
NAGINA CANAL
KHO RIVER
RAMGANGA
KALAGARH
DHARA
AFZALGARH
PANILI
HAREVALI BARRAGE
NAGINA
SHERKOT
KHO BARR.
KOTIRAI
DHAMPUR
NEHTOR
HALDOUR
KAROOLA RIVER
GANGAN RIVER
BAN RIVER
RAMGANGA CANAL
RAMGANGA
PHIKA
IKRA
SIAU KUND
CHANDPUR
NOORPUR
PHEENA

Fig. 1. Map of Bijnor District, U.P.

TABLE 1

LIST OF SPECIES

Zoological name	Local name	Locale	Availability	
			Seasonal	Numerical
Family CLUPEIDAE				
1. *Gadusia chapra* (Ham.)	Kuri	Dhabo, Ganges Ramganga	Summer months	Common
Family NOTOPTERIDAE				
2. *Notopterus chitala* (Ham.)	Moh, Chital	Ganges	Frequent in Summer	Common
3. *Notopterus notopterus* (Pallas)	Patra	Ganges, Kho Patheria	Throughout the year	Common
Family CYPRINIDAE				
4. *Amblypharyngodon mola* (Ham.)	Marhia	Ramganga Ganges	Throughout the year	Common
5. *Amblypharyngodon melettinus* (Cuv. & Val.)	Kayal	Ganges, Dhabo	In summer	Common
6. *Aspidoparia morar* (Ham.)	Moraki	Ponds, rivers	Occasionally available	
7. *Barbus chagunio* (Ham.)	Chhiban	Ganges	During winters	4 sp.
8. *Barbus sarana* (Ham.)	Dara	Ganges, Kho Ramganga	Throughout the year	Common
9. *Barbus* (*Tor*) *tor* (Ham.)	Mahasheer	Ramganga	,, ,, ,,	Common
10. *Barilius barila* (Ham.)	Bunca chal	Ramganga, Kho Ganges	,, ,, ,,	Common
11. *Barilius barna* (Ham.)	Popta	Ganges, Ponds	Uncommon	Rare
12. *Barilius bendelisis* (Ham.)	Jhorha	Ramganga, Kho	Throughout the year	Common
13. *Barilius bola* (Ham.)	Gulab	Ganges, Ramganga	Summer	Common
14. *Barilius modestus* (Day)	Popta	Ganges, Ponds	Uncommon	Rare
15. *Barilius vagra* (Ham.)	Popta	,, ,,	,,	,,
16. *Catla catla* (Ham.)	Katla	,, ,,	Throughout the year	Common
17. *Crossochilus latius* (Mukerjee) var. *punjabensis*	Rori	Ponds, rivers	Winter	Rare
18. *Cirrhina latia* (Ham.)	Kharhad	Ramganga, Kho	Throughout the year	Common
19. *Cirrhina reba* (Ham.)	Raia, Reva	Dhabo, Ganges	During summer	Common
20. *Cirrhina mrigala* (Ham.)	Mrigal	Ponds, Ganges	During summer	Common
21. *Danio devario* (Ham.)		Ponds	Throughout the year	Common
22. *Discognathus lamta* (Ham.)	Roharh	Ramganga, Kho	,, ,, ,,	,,

TABLE 1 (contd.)

23. *Discognathus modestus* (Day)	Guthloo	Ramganga	Throughout the year	Common
24. *Esomus danricus* (Ham.)		Riverine	Occasionally available	Rare
25. *Garra gotyla* (Gray)	Patharchal	Ramganga	” ”	”
26. *Labeo bata* (Ham.)	Bata	Ramganga, Ganges	During winter	3 sp.
27. *Labeo boga* (Ham.)	Bhangan	Ramganga	Throughout the year	Common
28. *Labeo calbasu* (Ham.)	Kalaunchh	Ganges, ponds	” ” ”	Common
29. *Labeo dero* (Ham.)	Chilva	Ponds, rivers	” ” ”	Common
30. *Labeo diplostomus* (Cuv. & Val.)	Moyal	Ganges, Kho Ramganga	” ” ”	”
31. *Labeo dyocheilus* (McClell.)	Pattharchatta	Ramganga	During winter	Rare
32. *Labeo gonius* (Ham.)	Kursa	Ganges, Malan	Throughout the year	Common
33. *Labeo pangusia* (Ham.)	Chilva	Ponds & rivers	” ” ”	fairly good numbers
34. *Labeo rohita* (Ham.)	Rohu	All rivers & ponds	” ” ”	Common
35. *Puntius chrysopterus* (McClell.)	Bhoorhi	Ponds, rivers	” ” ”	”
36. *Puntius conchonius* (Ham.)	Bhoorh	” ”	” ” ”	”
37. *Puntius punjabensis* (Day)	Bhoorh	Ponds	Specially after Monsoon	Small
38. *Puntius sophore* (Ham.)	Puthi	Ponds, Ganges	Seasonal occurrence	Rare
39. *Puntius stigma* (Ham.)	Bhoorh	Ponds, rivers	Throughout the year	Common
40. *Puntius terio* (Ham.)	Suria	Dhabo	” ” ”	”
41. *Puntius ticto* (Ham.)	Chaiti	Kho, Ramganga	During summer	Common
42. *Laubuca atpar* (Ham.)	Piocha	Ganges	Throughout the year	Common
43. *Oxygaster bacaila* (Ham.)	Chal	Rivers, Ponds	” ” ”	Common
44. *Oxygaster boopis* (Ham.)	Chal	” ”	” ” ”	”
45. *Rasbora daniconius* (Ham.)		Malan, Lakarhan	During summer	Rare
46. *Osteobrama alfrediana* (Gunther)	Gurda Chanda	Ponds, rivers	Throughout the year	Common
47. *Osteobrama cotio* (Ham.)	Gurda	Ponds, rivers	” ” ”	Common
Family COBITIDAE				
48. *Botia geto* (Ham.)	Bagatia	Ramganga, Pili	” ” ”	3 sp.
49. *Botia lohachata* (Chaudhri)	Billi	Ramganga, Khasan	” ” ”	2 sp.
50. *Lepidocephalichthys guntea* (Ham.)		Malan, Lakarhan	During summer	Rare
51. *Nemacheilus botia* (Ham.) var. *aureus*	Chatroo	Kho	During winter	Rare

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9. *Barbus* (*Tor*) *tor* (Ham.)	Mahasheer	Ramganga	,, ,, ,,	Common
10. *Barilius barila* (Ham.)	Bunea chal	Ramganga, Kho Ganges	,, ,, ,,	Common
11. *Barilius barna* (Ham.)	Popta	Ganges, Ponds	Uncommon	Rare
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14. *Barilius modestus* (Day)	Popta	Ganges, Ponds	Uncommon	Rare
15. *Barilius vagra* (Ham.)	Popta	,, ,,	,,	,,
16. *Catla catla* (Ham.)	Katla	,, ,,	Throughout the year	Common
17. *Crossochilus latius* (Mukerjee) var. *punjabensis*	Rori	Ponds, rivers	Winter	Rare
18. *Cirrhina latia* (Ham.)	Kharhad	Ramganga, Kho	Throughout the year	Common
19. *Cirrhina reba* (Ham.)	Raia, Reva	Dhabo, Ganges	During summer	Common
20. *Cirrhina mrigala* (Ham.)	Mrigal	Ponds, Ganges	During summer	Common
21. *Danio devario* (Ham.)		Ponds	Throughout the year	Common
22. *Discognathus lamta* (Ham.)	Roharh	Ramganga, Kho	,, ,, ,,	,,
23. *Discognathus modestus* (Day)	Guthloo	Ramganga	Throughout the year	Common
24. *Esomus danricus* (Ham.)		Riverine	Occasionally available	Rare
25. *Garra gotyla* (Gray)	Patharchal	Ramganga	,, ,,	,,
26. *Labeo bata* (Ham.)	Bata	Ramganga, Ganges	During winter	3 sp.
27. *Labeo boga* (Ham.)	Bhangan	Ramganga	Throughout the year	Common
28. *Labeo calbasu* (Ham.)	Kalaunchh	Ganges, ponds	,, ,, ,,	Common
29. *Labeo dero* (Ham.)	Chilva	Ponds, rivers	,, ,, ,,	Common
30. *Labeo diplostomus* (Cuv. & Val.)	Moyal	Ganges, Kho Ramganga	,, ,, ,,	,,
31. *Labeo dyocheilus* (McClell.)	Pattharchatta	Ramganga	During winter	Rare
32. *Labeo gonius* (Ham.)	Kursa	Ganges, Malan	Througbout the year	Common
33. *Labeo pangusia* (Ham.)	Chilva	Ponds & rivers	,, ,, ,,	fairly good numbers
34. *Labeo rohita* (Ham.)	Rohu	All rivers & ponds	,, ,, ,,	Common
35. *Puntius chrysopterus* (McClell.)	Bhoorhi	Ponds, rivers	,, ,, ,,	,,
36. *Puntius conchonius* (Ham.)	Bhoorh	,, ,,	,, ,, ,,	,,
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42. *Laubuca atpar* (Ham.)	Piocha	Ganges	Throughout the year	Common
43. *Oxygaster bacaila* (Ham.)	Chal	Rivers, Ponds	,, ,, ,,	Common
44. *Oxygaster boopis* (Ham.)	Chal	,, ,,	,, ,, ,,	,,
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47. *Osteobrama cotio* (Ham.)	Gurda	Ponds, rivers	,, ,, ,,	Common
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50. *Lepidocephalichthys guntea* (Ham.)		Malan, Lakarhan	During summer	Rare
51. *Nemacheilus botia* (Ham.) var. *aureus*	Chatroo	Kho	During winter	Rare

TABLE 1 (contd.)

52. *Nemacheilus corica* (Ham.)		Ganges	After rainy season	Rare
53. *Nemacheilus montanus* (McClell.)		Ponds, puddles	,, ,, ,,	Very small size
54. *Nemacheilus zonatus* (McCell.)		,, ,,	,, ,, ,,	
Family SILURIDAE				
55. *Ompok bimaculatus* (Bloch)	Papta	Ganges, Dhabo Patheria	During summer	Common
56. *Ompok pabda* (Ham.)	Ratgal	Ganges	During summer	Common
57. *Wallago attu* (Bloch & Schin)	Lachi	Riverine	During summer	Common
Family SCHILBEIDAE				
58. *Ailia colia* (Ham.)	Bansmati	Riverine	Throughout the year	Common
59. *Clupisoma garua* (Ham.)	Bakrhi	Ganges, Kho	During summer	Common
60. *Pseudotropis murius* (Ham.)	Bakrhi	Kho	During summer	Common
61. *Silonia silondia* (Ham.)	Silund	Ramganga	Throughout the year	Common
Family HETEROPNEUSTIDAE				
62. *Heteropneustes fossilis* (Bloch)	Singhee	Dhabo, Ban	Throughout the year	Common
Family BAGARIDAE				
63. *Mystus aor* (Ham.)	Aore	Riverine	Throughout the year	Less common than *Seenghala*
64. *Mystus bleekeri* (Day)	Kater	Ramganga	Throughout the year	Common
65. *Mystus cavasius* (Ham.)	Kater	Rivers & ponds	,, ,, ,,	Common
66. *Mystus corsula* (Ham.)	Kater	Ponds	,, ,, ,,	Common
67. *Mystus tengara* (Ham.)	Tengan	Ponds & rivers	,, ,, ,,	Common
68. *Mystus vittatus* (Bloch)	Tengan	Ponds & rivers	,, ,, ,,	Common
69. *Mystus seenghala* (Sykes)	Singhara	Ganges	Throughout the year	Common
70. *Rita rita* (Ham.)	Khagga	Riverine	During summer	Rare
Family CHACIDAE				
71. *Chaca chaca* (Ham.)	Chandan	Ganges, Ramganga	After rainy season	Rare
Family CLARIDAE				
72. *Clarias magur* (Cuv. & Val.)	Magura	Ponds, rivers	Throughout the year	Common
Family SISORIDAE				
73. *Bagarius bagarius* (Ham.)	Gaunchh	Ganges, Ramganga	Throughout the year	Common
74. *Gagata nangra* (Ham.)	Padna	Ramganga, Khasan	,, ,, ,,	Common
75. *Gagata viridescens* (Ham.)	Padna	,, ,,	,, ,, ,,	Common

Table 1 (contd.)

76. *Glyptothorax telchitta* (Ham.)	Tilier	Ramganga	Rainy season	Common
77. *Sisor rhabdophorus* (Ham.)	Chamla	Ganges	During summer	Rare
Family Channidae				
78. *Channa gachua* (Ham.)	Chinga	Patheria	During summer	Common
79. *Channa marulius* (Ham.)	Sol	Ramganga, Dhabo	Throughout the year	Common
80. *Channa punctatus* (Bloch)	Sol	Ponds & rivers	Throughout the year	Common
81. *Channa striatus* (Bloch)	Sol	Ponds & rivers	Throughout the year	Common
Family Ambassidae				
82. *Glossobius giuris* (Ham.)	Gulva	Malan, Kho, Ganges	Throughout the year	Common
Family Abbassidae				
83. *Ambassis nama lalius* (Cuv. & Val.)	Bakra	Riverine	Throughout the year	Common
84. *Ambassis ranga* (Ham.)	Chandla	Riverine	Throughout the year	Common
Family Anabantidae				
85. *Colisa* (*Trichogaster*) *fasciatus* (Bloch)	Kanghi Kharda	Pili, Patheria Dhabo	Throughout the year	Common
86. *Colisa* (*Trichogaster*) *lalius* (Cuv. & Val.)	Kanghi	Ganges, ponds	Throughout the year	Common
87. *Anabas testudinus* (Cuv.)		Ganges	Rarely available	2 sp.
88. *Nandus nandus* (Ham.)	Khasso, Gadha	Riverine	Throughout the year	Plenty
Family Mugilidae				
89. *Mugil corsula* (Ham.)	Tara	Riverine	After rains	Rare
90. *Mugil cascasia* (Ham.)	Khaksi	Riverine	After rains	Rare
Family Belonidae				
91. *Belone cancila* (Ham.)	Sua	Ponds & rivers	Frequent in winters	
Family Mastacembelidae				
92. *Macrognathus acculateus* (Bloch)	Gaind	Ramganga	During summer	Rare
93. *Macrognathus armatus* (Lace.)	Bam	Ramganga, Ganges Patheria	Frequent	Plenty
94. *Macrognathus pancalus* (Ham.)	Jugan	Ramganga, Kho Dhabo	Throughout the year	Plenty
Family Amphipnoidae				
95. *Amphipnous cuchia* (Ham.)	Andhal Sanp	Ponds	During summer	Rare

TABLE 1 (contd.)

52. *Nemacheilus corica* (Ham.)		Ganges	After rainy season	Rare
53. *Nemacheilus montanus* (McClell.)		Ponds, puddles	„ „ „	Very small size
54. *Nemacheilus zonatus* (McCell.)		„ „	„ „ „	
Family SILURIDAE				
55. *Ompok bimaculatus* (Bloch)	Papta	Ganges, Dhabo Patheria	During summer	Common
56. *Ompok pabda* (Ham.)	Ratgal	Ganges	During summer	Common
57. *Wallago attu* (Bloch & Schin)	Lachi	Riverine	During summer	Common
Family SCHILBEIDAE				
58. *Ailia colia* (Ham.)	Bansmati	Riverine	Throughout the year	Common
59. *Clupisoma garua* (Ham.)	Bakrhi	Ganges, Kho	During summer	Common
60. *Pseudotropis murius* (Ham.)	Bakrhi	Kho	During summer	Common
61. *Silonia silondia* (Ham.)	Silund	Ramganga	Throughout the year	Common
Family HETEROPNEUSTIDAE				
62. *Heteropneustes fossilis* (Bloch)	Singhee	Dhabo, Ban	Throughout the year	Common
Family BAGARIDAE				
63. *Mystus aor* (Ham.)	Aore	Riverine	Throughout the year	Less common than *Seenghala*
64. *Mystus bleekeri* (Day)	Kater	Ramganga	Throughout the year	Common
65. *Mystus cavasius* (Ham.)	Kater	Rivers & ponds	„ „ „	Common
66. *Mystus corsula* (Ham.)	Kater	Ponds	„ „ „	Common
67. *Mystus tengara* (Ham.)	Tengan	Ponds & rivers	„ „ „	Common
68. *Mystus vittatus* (Bloch)	Tengan	Ponds & rivers	„ „ „	Common
69. *Mystus seenghala* (Sykes)	Singhara	Ganges	Throughout the year	Common
70. *Rita rita* (Ham.)	Khagga	Riverine	During summer	Rare
Family CHACIDAE				
71. *Chaca chaca* (Ham.)	Chandan	Ganges, Ramganga	After rainy season	Rare
Family CLARIDAE				
72. *Clarias magur* (Cuv. & Val.)	Magura	Ponds, rivers	Throughout the year	Common
Family SISORIDAE				
73. *Bagarius bagarius* (Ham.)	Gaunchh	Ganges, Ramganga	Throughout the year	Common
74. *Gagata nangra* (Ham.)	Padna	Ramganga, Khasan	„ „ „	Common
75. *Gagata viridescens* (Ham.)	Padna	„ „	„ „ „	Common

TABLE 1 (contd.)

76. *Glyptothorax telchitta* (Ham.)	Tilier	Ramganga	Rainy season	Common
77. *Sisor rhabdophorus* (Ham.)	Chamla	Ganges	During summer	Rare
Family CHANNIDAE				
78. *Channa gachua* (Ham.)	Chinga	Patheria	During summer	Common
79. *Channa maculius* (Ham.)	Sol	Ramganga, Dhabo	Throughout the year	Common
80. *Channa punctatus* (Bloch)	Sol	Ponds & rivers	Throughout the year	Common
81. *Channa striatus* (Bloch)	Sol	Ponds & rivers	Throughout the year	Common
Family AMBASSIDAE				
82. *Glossobius giuris* (Ham.)	Gulva	Malan, Kho, Ganges	Throughout the year	Common
Family ABBASSIDAE				
83. *Ambassis nama lalius* (Cuv. & Val.)	Bakra	Riverine	Throughout the year	Common
84. *Ambassis ranga* (Ham.)	Chandla	Riverine	Throughout the year	Common
Family ANABANTIDAE				
85. *Colisa* (*Trichogaster*) *fasciatus* (Bloch)	Kanghi Kharda	Pili, Patheria Dhabo	Throughout the year	Common
86. *Colisa* (*Trichogaster*) *lalius* (Cuv. & Val.)	Kanghi	Ganges, ponds	Throughout the year	Common
87. *Anabas testudinus* (Cuv.)		Ganges	Rarely available	2 sp.
88. *Nandus nandus* (Ham.)	Khasso, Gadha	Riverine	Throughout the year	Plenty
Family MUGILIDAE				
89. *Mugil corsula* (Ham.)	Tara	Riverine	After rains	Rare
90. *Mugil cascasia* (Ham.)	Khaksi	Riverine	After rains	Rare
Family BELONIDAE				
91. *Belone cancila* (Ham.)	Sua	Ponds & rivers	Frequent in winters	
Family MASTACEMBELIDAE				
92. *Macrognathus acculateus* (Bloch)	Gaind	Ramganga	During summer	Rare
93. *Macrognathus armatus* (Lace.)	Bam	Ramganga, Ganges Patheria	Frequent	Plenty
94. *Macrognathus pancalus* (Ham.)	Jugan	Ramganga, Kho Dhabo	Throughout the year	Plenty
Family AMPHIPNOIDAE				
95. *Amphipnous cuchia* (Ham.)	Andhal Sanp	Ponds	During summer	Rare

run through it from north to south. These are Malan, Kho, Dhara, Pili, Panili, Phica and Khasan rivers. There are some seasonal rivers such as Ban, Gangan, Karula, Patheria, and Dhabo. Moreover there is the Ramganga canal arising from Kalagarh. In addition to these there are numerous perennial and seasonal ponds and lakes all over the district such as Khokra pond, Dharmnagari Dhaya, Chahshirin pond and Siau Kund which are fed by local canals, distributaries, flood and rain water drains. This richness of water resources has resulted in a varied fish-fauna fairly representatives of the north Indian freshwaters.

DISCUSSION

About 75% of the recorded fishes belong to a single Order, Cypriniformes. Atleast 33% of the fishes listed are of considerable economic importance as edible fishes. A number of fishes are known to have varying degrees of accessory breathing capacity and possess remarkable accessory respiratory organs: *Rita rita, Clarias magur, Chaca chaca, Channa punctatus, Channa marulius, Channa striatus, Amphipnous cuchia, Nandus nandus, Heteropneustes fossilis, Glossobius giuris* and they can live without water for a considerable time.

The regular availability of *Clarias magur* from a number of ponds in the district throughout the year agrees with the report by Mahajan (1963) but is interesting in view of the report by Sinha & Shiromny (1953) that the species has only a localised distribution, being found only in a few ponds at Garhmukteshwar in the months of April, May and June. It appears that the fishes are present throughout the year in these ponds and find a safe place in the bottom of the ponds which is their natural habitat, while they are easily netted only in April, May and June as most of the water dries up at that time and the level is the lowest. The distribution of *Mystus corsula* is reported by Day (1878) to be from Orissa through Bengal and Assam. The only report of its occurrence in this region is by Sinha and Shiromny (1953) from Hindon nadi in Meerut district and by Mahajan (1963) from Muzaffarnagar district. Similarly *Sicamugil* (*Mugil*) *cascasia* has been recorded by Day from rivers of north-west provinces of Assam. The only report of the occurrence of this species in this region is from Jamuna river from Delhi State by Mahajan (1963) from Kali nadi, Muzaffarnagar.

A number of genera *viz., Barilius, Garra, Labeo, Gagata, Nemacheilus, Glyptothorax, Barbus* and *Crossochilus,* characteristic of hill-streams are found here. A few of them have also been recorded by Mahajan (1963) from Muzaffarnagar District. The only possible explanation of their occurrence is that they are swept along the current due to the presence of an excessive slope described in the topography of the disrtict.

Chaca chaca of family Chacidae is a common fish of this region which not been reported earlier except for a single specimen obtained by Mahajan (1963). The *Anabas testudinus* occurs throughout the district, although only two specimens were obtained from fish markets where fishes come only from Ganges.

ACKNOWLEDGEMENT

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MATERIAL FOR THE FLORA OF MAHABALESHWAR - 7

P. V. BOLE AND M. R. ALMEIDA

[*Continued from Vol.* 82(1): 86]

ULMACEAE

1. Leaves glabrous, broadly ovate .... *Celtis*
1. Leaves with white pubescence beneath, ovate-lanceolate .... *Trema*

Celtis Linn.

1. **Celtis cinnamomea** Lindl. ex Planch., in Ann. Sci. Nat. ser. 3, 10: 303, 1848; FBI 5: 482; Cooke, T. 2: 630 (3: 128); Talbot 2: 299, t. 14.

C. wightii Planch., in Ann. Sci. Nat. ser. 3, 10: 307, 1848, Wight, Icon. t. 1969, 1953; Cooke, T. 2: 631 (3:129).

Rare tree in forest areas along Fitzgerald Ghat.

FLOWERS & FRUITS: February-May.

Trema Lour.

1. **Trema orientalis** (Linn.) Blume, Mus. Bot. Lugd. Bat. 2: 58, 1856; FBI 5: 484; Cooke, T. 2: 631 (3: 129-30); Talbot, 2: 500, t. 515; Nairne, 303.

Celtis orientalis Linn. Sp. Pl. 1044, 1753; Graham, 189, 1839.

Sponia wightii Planch., in Ann. Sci. Nat. ser. 3, 10: 322, 1848; Wight, Icon. t. 1971, 1853; Dalzell & Gibson, 238, 1861.

Trema wightii (Planch.) Cooke, T. Gazett. Bombay, 649, 1885.

Rare tree at Mahabaleshwar. Only one specimen has been collected from Fitzgerald Ghat.

FLOWERS: December.

LOCAL NAMES: Gol, Ghol.

URTICACEAE

1. Leaves and stem with stinging hairs.......... 2
  2. Ovary oblique; an annual herb ..... *Laportea*
  2. Ovary straight; a perennial herb....*Girardinia*
1. Leaves and stem without stinging hairs 3
  3. Female perianth 3-5 partite or obsolete .... *Lecanthus*
  3. Female perianth tubular, shortly toothed or sub-entire, enclosing the achenes 4
    4. Fruiting perianth fleshy; stigma penicillate .... *Debregeasia*
    4. Fruiting perianth dry, numerous; stigma filiform 5
      5. Shrubs; stigma persistant .... *Boehmeria*
      5. Herbs, stigma jointed, deciduous .... *Pouzolzia*

Boehmeria Jacq.

1. **Boehmeria scabrella** (Roxb.) Gaud., in Frey. Voy. 500, 1826; Cooke, T. 2: 636 (3: 135); Santapau, 310, 1963.

Urtica scabrella Roxb., Fl. Ind. 3: 581, 1832; Wight, Icon. t. 691, 1841.

Splitgerbera scabrella Dalz. & Gibs. Bombay Fl. 239, 1861.

B. platyphylla Don var. *seabrella* Wedd. Mon. 365, 1856; FBI 5: 578; Birdwood, 26, 1897.

Very common and often very gregarious shrub along the edges of the forest, in partially shaded places.

FLOWERS & FRUITS: September-December.

Debregeasia Gaud.

1. **Debregeasia longifolia** (Burm. f.) Wedd., in DC. Prodr. 16: 235, 1869; Cooke, T. 649, 1885; Santapau, 288; Vartak, J. Univ. Poona, 18: 97, 1960.

Urtica longifolia Burm. f., Fl. Ind. 197, 1768.

D. velutina Gaud., Bot. Voy. Bonite, t. 90, 1844-6; FBI 5: 590; Birdwood, 26, 1897; Cooke, T. 2: 640 (3: 139); Puri & Mahajan, 132, 1960.

Conocephalus niveus Wight, Icon. t. 1959, 1853; Dalz. & Gibs. 239, 1861.

Boehmeria ramiflora Graham, Cat. Bombay Pl. 187, 1839.

Rare shrub near water-courses and on sides of streams.

FLOWERS: December.

LOCAL NAME: Kapsi.

Laportea Gaud.

1. **Laportea interrupta** (Linn.) Chew., Gard. Bull. Straits Settlm. 21: 200, 1965; T. P. Ramamurthy, in Fl. Hassan Dist. 89, 1976.

Fleurya interrupta Gaud. in Freyc. Voy. Bot. 497, t. 8, 1826; Dalz. & Gibs. 238; Wight Icon. t. 1975, 1853; FBI 5: 548; Birdwood, 26, 1895.

Urtica interrupta Linn. Sp. Pl. 985, 1753; Graham, 187.

Rare herb in waste-lands and among the undergrowth along the margins of the forests.

FLOWERS: July-August.

LOCAL NAME: Khajoti.

Lecanthus Wedd.

1. **Lecanthus peduncularis** (Wall. ex Royle) Wedd., in DC. Prodr. 16: 164, 1869 (p.p.): Santapau, 400, 1962 & 310, 1963.

Procris peduncularis Wall. ex Royle, Ill. t. 83, f. 2, 1839.

L. wallichii Wedd., in Ann. Sci. Nat. Bot. ser. 4, 1: 187, 1854; Cooke, T. 2: 634 (3: 133).

L. wightii Wedd., l.c.; FBI 5: 559; Birdwood, 26, 1897; Cooke, T. l.c.

Elatostemma oppositifolium Dalz. in Kew Journ. Bot. 3: 179, 1851; Dalz. & Gibs. 239; Cooke, T. 651, 1885.

E. ovata Wight, Icon. t. 1985, 1852.

Common herb on old walls and on tree-trunks in latter half of the monsoon.

FLOWERS & FRUITS: August-September.

Girardinia Gaud.

1. **Girardinia zeylanica** Decne, in Jacq. Voy. 152, 1844; Cooke, T. 2: 633 (3: 132); Puri & Mahajan, 132, 1960; Santapau, 254.

Urtica heterophylla Roxb. Fl. Ind. 3: 586, 1832; Graham, 187; Wight, Icon. t. 1687, 1851.

G. heterophylla Dalz. & Gibs. Bombay Fl. 238, 1861 (non Decne, 1844); Cooke, T. 651, 1885; Birdwood, 26, 1897.

G. heterophylla Decne var. *zeylanica* Hook. f., in Fl. Brit. India, 5: 551, 1888.

Common stinging nettle along road-sides. Stinging hairs cause skin irritation and produce quite large blisters.

FLOWERS & FRUITS: September-November.

LOCAL NAMES: Moti Khojati, Aghada.

Pouzolzia Gaud.

1. **Pouzolzia zeylanica** (Linn.) Benn., Pl. Jav. Rar. 67, 1838; Santapau, 310, 1963.

Paritaria zeylanica Linn., Sp. Pl. 1052, 1753.

P. indica Linn. Mant. 1: 128, 1767; Graham, 187.

Pouzolzia indica (Linn.) Gaud. Bot. Frey. Voy. 503, 1826; FBI 5: 581; Dalz. & Gibs. 240; Wight, Icon. 1980, f. 1 & t. 2100, f. 40, 1853; Cooke, T. 2: 638 (3: 137).

Rare herb on slopes of Fitzgerald Ghat.

FLOWERS & FRUITS: July-September.

CANNABIDACEAE

1. **Cannabis sativa** Linn. Sp. Pl. 1027, 1753; Graham, 187; Dalz. & Gibs. suppl. 79; Lisboa, 223; FBI 5: 487.

C. indica Lamk., Encycl. Method. 1: 695, 1783.

This species is included here on the authority of Lisboa. We have not seen any specimen, in any of the herbaria visited.

LOCAL NAMES: Bhang, Ganja, Hemp.

MORACEAE

1. Stamens inflexed in buds; anthers reversed .... *Morus*
1. Stamens and anthers erect in buds 2

2. Flowers on the inner wall of a close receptacle .... *Ficus*
2. Flowers in globose, oblong or cylindric heads .... *Artocarpus*

Artocarpus J. R. Forest & G. Forst

1. **Artocarpus heterophyllus** Lamk. Encycl. 3: 210, 1789; Jarett, in Arn. Arbor. 40: 334, 1959.

A. integrifolia Graham, Cat. Bombay Pl. 192, 1839 (non. Linn. 1781): Dalz. & Gibs. 244; FBI 5: 541; Lisboa, 223; Birdwood, 26, 1897; Cooke, T. 2: 657 (3: 158).

A. integrifolia Linn. var. *heterophylla* Pers., Syn. Pl. 2: 531, 1807.

Rare cultivated tree in private gardens.

FLOWERS & FRUITS: December-May.

LOCAL NAMES: Phanas, Jack-fruit.

Ficus Linn.

1. Male, gall and female flowers in the same receptacle 2
  2. Stamens 1 3
    3. Petioles short, stout, never joined to the blade 4
      4. Leaves more or less tomentose 5
        5. Leaves obtuse; receptacles puberulous, globose, red .... *F. bengalensis*
        5. Leaves bluntly apiculate; receptacle pisciform, grey-tomentose .... *F. tomentosa*
      4. Leaves glabrous .... *F. retusa*
    3. Petioles long, slender sometimes joined to the blade 6
      6. Apices of leaves caudate-acuminate 7
        7. Apical tail half as long as blade .... *F. religiosa*
        7. Apical tail less than 1/5th as long as blade 8
          8. Bases of leaves cordate 9
            9. Peduncles 0.2-0.4 in. long .... *F. arnottiana*
            9. Peduncles 0.5-1.0 in. long .... *F. palmata*
          8. Bases of leaves tapering .... *F. rumphii*
      6. Apices of leaves not caudate-acuminate .... *F. infectoria*
  2. Stamens 2 .... *F. racemosa*
1. Male and gall flowers in one set or receptacle and fertile and female flowers in another 10
10. Male flowers with 2 stamens .... *F. racemosa*
10. Male flowers with one stamen 11
  11. Leaves at least some opposite .... *F. hispida*
  11. Leaves all alternate 12
    12. Creeping shrubs; bracts present .... *F. heterophylla*
    12. Erect shrubs; bracts absent .... *F. asperrima*

1. **Ficus asperrima** Roxb. Fl. Ind. 3: 554, 1832; Graham, 191; Wight, Icon. t. 633, 1843; Dalz. & Gibs. 243; FBI 5: 522, 1888; Cooke, T. 2: 653 (3: 153); Birdwood, 26, 1897; Santapau, 258.

Rare tree along the edges of the forests along Fitzgerald ghat.

FLOWERS & FRUITS: January-April.

LOCAL NAME: Kharvat.

2. **Ficus bengalensis** Linn. Sp. Pl. 1059, 1753; FBI 5: 499; Birdwood, 26, 1897; Cooke, T. 2: 645 (3: 145); Puri & Mahajan, 132.

F. indica Linn. Amoem. Acad. ed. 3, 1: 27, 1787; Graham, 189.

Urostigma bengalense Gasp. Nov. Gen. Ficus 7, 1844; Wight, Icon. t. 1989, 1853; Dalz. & Gibs. 240.

Quite common tree all over in open sunny places.

FLOWERS & FRUITS: February-June.

LOCAL NAME: Wad.

3. **Ficus carica** Linn. Sp. Pl. 1059, 1753; Graham, 191; Dalz. & Gibs. suppl. 80; Cooke, T. 2: 655 (3: 155).

F. virgata Roxb. Fl. Ind. 3: 530, 1832; Lisboa, 223; Puri & Mahajan, 133, 1960.

Rare shrub, cultivated for its fruits in gardens.

FLOWERS & FRUITS: January-March.

LOCAL NAME: Anjir.

4. **Ficus arnottiana** Miq., Ann. Mus. Lugd. Bat. 3: 287, 1867; FBI 5: 513; Cooke, T. 2: 649 (3: 149).

F. cordifolia Graham Cat. 192, 1839 (non Roxb. 1832); Lisboa, 223; Cooke, T. 648, 1885.

Urostigma cordifolium Dalz. & Gibs. Bombay Fl. 242, 1861 (non Miq., 1859).

Rare tree on hard rocky grounds or sometimes found on rocks and broken walls.

FLOWERS & FRUITS: December-April.

LOCAL NAMES: Pair, Asit.

5. **Ficus heterophylla** Linn. f., suppl. 442, 1781; Graham, 191; Dalz. & Gibs. 243: Wight, Icon. t. 659, 1843; Cooke, T. 2: 652 (3: 152); Birdwood, 26, 1897.

F. acutiloba Miq. in Hook. Lond. J. Bot. 7: 227, 1848; Dalz. & Gibs. 243.

Rare scandent shrub on sides of streams.

FLOWERS & FRUITS: March-July.

LOCAL NAME: Karoti (Birdwood).

6. **Ficus hispida** Linn. f. suppl. 442, 1781; FBI 5: 522; Cooke, 2: 653 (3: 154); Birdwood, 26, 1897; Santapau, 301, 1963.

F. oppositifolia Willd. Sp. Pl. 4: 1151, 1805; Graham, 191; Wight, Icon. t. 638.

Covellia oppositifolia Gasp. Ricer Caprif. 85, 1845; Dalz. & Gibs. 243.

C. daemonum Miq. in Hook. Lond. Journ. Bot. 7: 462, 1848.

F. daemona Koen., in Graham, Cat. Bombay Pl. 192, 1819; Wight, Icon. t. 641, 1843.

Rare shrub on slopes of Fitzgerald ghat and along the banks of streams.

FLOWERS & FRUITS: March-July.

LOCAL NAMES: Kala Umbar, Bodeda.

7. **Ficus lacor** Buch.-Ham., in Linn. Trans. 15: 150, 1825.

F. infectoria Roxb., Fl. Ind. 3: 551, 1832 (Excl. syn. of Rheede) (non Willd., 1806); Graham, 191; Wight, Icon. t. 665, 1844; FBI 5: 515; Birdwood, 26, 1897; Cooke, T. 2: 241 (3: 151).

Urostigma infectorium Miq., Fl. Ind. Bat. 1(2): 339, 1859; Dalz. & Gibs. 241.

FLOWERS & FRUITS: October-March.

LOCAL NAMES: Kel, Bassari, Pipli.

8. **Ficus racemosa** Linn. Sp. Pl. 1060, 1753.

F. glomerata Roxb., Pl. Corom. 2: 13, t. 123, 1798; Graham, 190; Wight, Icon. t. 667, 1843; Cooke, T. 648 & 2: 654 (3: 154); Lisboa, 223, Birdwood, 26, 1897; Puri & Mahajan, 133, 1960; Santapau, 399, 1962 & 301, 1963.

Covellia glomerata Miq., in Hook. Lond. Journ. Bot. 7: 465, 1848; Dalz. & Gibs. 243.

Common tree all over along sides of streams and also along road-sides.

FLOWERS & FRUITS: Throughout the year.

LOCAL NAMES: Umbar, Rumad.

9. **Ficus religiosa** Linn., Sp. Pl. 1059, 1753; Graham, 190; FBI 5: 513; Birdwood, 26, 1897; Cooke, T. 2: 649 (3: 149).

Urostigma religiosa Gasp., Ricer. Caprif. 82, t. 7, f. 1-5, 1845; Wight, Icon. t. 1967, 1853; Dalz. & Gibs. 241.

Common tree all over.

FLOWERS & FRUITS: March-July.

LOCAL NAMES: Pipal, Astha, Ashit.

10. **Ficus retusa** Linn. Mantissa 129, 1767; FBI 5: 511; Birdwood 26, 1897; Cooke, T. 2: 647 (3: 146-7).

F. benjamina Willd., Sp. Pl. 4: 1143, 1806 (non Linn. 1767): Graham, 191.

Urostigma nitidum Miq., in Hook. Lond. Journ. Bot. 6: 582, 1847; Dalz. & Gibs. 242.

U. retusum Gasp., Nov. Gen. Ficus 7, 1844.

Rare tree along road-sides on way to Panchgani and along Fitzgerald ghat.

FLOWERS & FRUITS: September-March.

LOCAL NAMES: Nandruk, Raneikut.

11. **Ficus rumphii** Blume, Bijdr. 437, 1825; FBI 5: 512, 1888; Cooke, T. 2: 648 (3: 148); Birdwood, 26, 1897; Puri & Mahajan, 133, 1960.

F. cordifolia Roxb., Fl. Ind. 3: 548, 1832 (non Blume 1825); Wight, Icon. t. 640, 1843.

Rare species along road-sides.

FLOWERS & FRUITS: February-July.

LOCAL NAMES: Pair, Ashtha, Pahir.

12. **Ficus tomentosa** Roxb., Fl. Ind. 3: 550, 1832; Wight, Icon. t. 647, 1843; Birdwood, 26, 1890; Cooke, T. 2: 646 (3: 146).

There are few trees of this species planted along road-side between Mahabaleshwar and Panchgani.

FLOWERS & FRUITS: January-April.

LOCAL NAMES: Karvat, Kallugoli.

13. **Ficus palmata** Forsk., Fl. Aegypt. 179, 1775; FBI 5: 530; Birdwood 26, 1897; Nairne, 308.

F. caricoides Roxb., Fl. Ind. 3: 529, 1832; Wight, Icon. t. 649, 1843; Cooke, T. 648, 1885.

According to Birdwood this is a common fig at Mahabaleshwar. We have not found it on the plateau and there is no herbarium specimen in any of the herbaria consulted. We include it here on authority of Cooke and Birdwood.

Morus Linn.

1. **Morus alba** Linn. Sp. Pl. 986, 1753; Graham, Cat. 194; Dalz. & Gibs. suppl. 80; FBI 5: 492; Birdwood, 26, 1897; Cooke, T. 2: 658 (3: 159); Puri & Mahajan, 133, 1960.

M. atropurpurea Roxb., Fl. Ind. 3: 595, 1832; Cooke, T. 648, 1885; FBI 5: 491, 1888.

Commonly cultivated for its edible fruits and for leaves which are used for feeding silkworms in sericulture.

FLOWERS & FRUITS: September-December.

CASUARINACEAE

Casuarina Adans.

1. **Casuarina equisetifolia** J. R. Forst & G. Forst, Char. Gen. 104, t. 52. 1776; Dalz. & Gibs. Suppl. 82, 1861; FBI 5: 598; Birdwood, 26, 1897; Puri & Mahajan, 133, 1960.

C. muricata Roxb., Fl. Ind. 3: 519, 1832; Graham, 196; Dalz. & Gibs. suppl. 82.

Rare tree planted along road-sides and on hill-slopes by forest department. The tree is considered to be a very good wind-break.

FLOWERS & FRUITS: September-December.

LOCAL NAMES: Suru, Beef-wood, Cassowary tree.

FAGACEAE

Quercus Linn.

1. **Quercus robur** Linn. Sp. Pl. 996; 1753; Birdwood, 26, 1897.

There are a few planted trees at Sindola. According to Birdwood these trees were raised from acorns brought by Dr. John Wilson, from Scotland.

SALICACEAE

Salix Linn.

1. **Salix tetrasperma** Roxb., Pl. Cor. 1: 66, t. 97, 1795; Graham, 195; Wight, Icon. t. 1954, 1853; Dalz. & Gibs. 220; Lee, 466, 1885; Cooke, T. 648, 1885 & 2: 661 (3: 162); FBI 5: 626; Lisboa, 222; Birdwood 26, 1897; Puri & Mahajan, 133; Santapau, 261, 1963.

Common tree in spring beds along Yenna River. Elegant tree, especially when in flowers, bearing catkin-like spikes.

FLOWERS & FRUITS: October-December.

LOCAL NAMES: Walunj, Indian Willow.

Cupressaceae

Cupressus Linn.

1. **Cupressus sempervirens** Linn. Sp. Pl. 1002, 1753; FBI 5: 645; Cooke 2: 666 (3: 168).

Rare cultivated tree at Wilson Point.

CONE FORMATION: December.

LOCAL NAME: Suruboke.

Gnetaceae

Gnetum Linn.

1. **Gnetum ula** Brongn. in Duperrey, Voy. Coquille 12, 1829; Birdwood, 27, 1897; Santapau, 297, 1963. *G. funiculata* Smith ex Wight, Icon. t. 1955, 1853. *G. scandens* Roxburgh, Fl. Ind. 3: 518, 1832; Graham, 188; Dalz. & Gibs. 246; Talbot, For. Fl. 2: 543, f. 537.

Rare lofty climber on tall trees in Fitzgerald Ghat.

CONE FORMATION: December-March.

LOCAL NAMES: Kombal, Wumbli.

Ginkgoaceae

1. **Ginkgo biloba** Linn. Mant. 2: 313, 1771; Bailey, Manual cult. pt. 99, 1949.

Rare plant in cultivation in private gardens at Mahabaleshwar, but only grown as a potted plant and never grows to be a shrub.

LOCAL NAME: Maiden Hair-Tree.

Hydrocharitaceae

1. Stems well-developed, branching ...... *Hydrilla*
1. Stems rhizomatous 2
    2. Perianth of a single row ...... *Vallisneria*
    2. Perianth of two rows .... *Blyxa*

Blyxa Noronha ex Thouars

1. Seeds spinescent with long filiform tails at each end .... *B. echinosperma*
1. Seeds without tails .... *B. octandra*

1. **Blyxa echinosperma** (Clarke) Hook. f., in Fl. Brit. Ind. 5: 661, 1888; Cooke, T. 2: 671 (3: 172) (Pro parte); Birdwood, 27, 1897; Puri & Mahajan, 133, 1960.

Hydrotrophus echinospermus C. B. Clarke, in J. Linn. Soc. 14: 8, t. 1, 1875.

This species is reported here on authority of Cooke, Birdwood as well as Puri & Mahajan. We have not seen any authentic specimen from Mahabaleshwar. Specimens in Blatter Herbarium, which have been identified as belonging to this species have all turned out to be *B. octandra* (Roxb.) Planch ex Thwaites.

2. **Blyxa octandra** (Roxb.) Planch ex Thwaites, Enum. Pl. Zeyl. 332, 1864; Santapau, 297; Den Horteg, in Fl. Malesiana 5(9): 392, 1957.

Vallisneria octandra Roxb. Pl. Cor. 2: 34, t. 165, 1798; Graham, 199.

B. roxburghii Rich., in Mem. Inst. Fr. 77, t. 5, 1811; FBI 5: 660; Cooke, T. 2: 670 (3: 172).

Rather rare herb in shallow waters along the edges of the Yenna lake and also in rice-fields. Leaves spreading on the surface of the soil. Flowers white, erect above water.

FLOWERS: October-February.

Hydrilla Rich.

1. **Hydrilla verticillata** (Linn. f.) Presl., Bot. Bemerk. 112, 1844; Dalz. & Gibs. 277; FBI 5: 659; Cooke, T. 2: 668 (3: 170).

Serpicula verticillata Linn. f., suppl. 416, 1781; Graham, 76.

H. ovalifolia Rich., Mem. Inst. Fr. 12(2): 76, t. 2, 1811.

Common submerged herb in Yenna lake and in stagnant waters in rice-fields.

FLOWERS: December.

LOCAL NAME: Sheval.

Burmanniaceae

Burmannia Linn.

1. **Burmannia pusilla** (Miers.) Thwaites, Enum. Pl. Zeyl. 325, 1864; FBI 5: 665; Santapau, 262, 1967.

B. coelestis Don var. *pusilla* Triman, Handb. Fl. Ceyl. 4: 131, 1898; Nairne 318; Cooke, T. 2: 672 (3: 174); Puri & Mahajan, 133, 1960.

B. coelestis Fish., in Fl. Madras Pres. 1399, 1928 (non Don, 1825); Birdwood, 27, 1897.

B. triflora Roxb., Fl. Ind. 2: 117, 1832 (p. p.); Dalz. & Gibs. 271; Cooke, T. 651, 1885.

B. disticha Graham, Cat. Bombay Pl. 223, 1839 (non Linn., 1753).

Gonyanthes pusilla Miers., in Trans. Linn. Soc. 18: 537, t. 38, f. 3, 1841.

Very common and gregarious herb in wet places, generally hidden among the grasses.

FLOWERS & FRUITS: September-January.

Note: T. P. Ramamurthy in Saldanha & Nicolson, Fl. Hassan District, treats this taxon as synonymous with *B. coelestis* Don giving citation of Janker, in Steenis, Fl. Malesiana Ser. I, 4: 17, 1948. However Ramamurthy has confused the nomenclature and synonymy followed by him is definitely not the same as that of Janker, cited in either of the two references. Rev. Fr. H. Santapau (Fl. Khandala, ed. 3, 262) has not cited basionym of specific epithet "pusilla" and misquoted page 30 for 130, otherwise giving the clear and correct nomenclature.

ORCHIDACEAE

1. Epithytic or lithophytic plants 2

2. Plants with distinct pseudobulbs 3

3. Pseudobulbs with 2 or more nodes 4

4. Pseudobulbs flattened, discoid or rotund .... *Eria*

4. Pseudobulbs elongated, ovoid or conical 5

5. Pedicels and ovary sparsely pubescent; pollinia 8, pyriform .... *Eria* (*E. mysorensis*)

5. Pedicels and ovary glabrous; pollinia 4, linear or linear-oblong .... *Dendrobium*

3. Pseudobulb with a single node .... *Cirrhopetalum*

2. Plants without pseudobulbs 6

6. Leaves membranaceous, plicate; lip superior .... *Malaxis* (P.P.)

6. Leaves fleshy or coriaceous, not plicate; lip inferior 7

7. Plants without distinct stem; leaves radical .... *Oberonia*

7. Plants with a distinct stem; leaves cauline 8

8. Leaf-apex irregularly toothed with 1-3 sharp teeth .... *Rhynchostylis*

8. Leaf-apex bilobed, lobes unequal or sub-equal, rounded or sub-acute 9

9. Stem short, ± 5 cm long .... *Smithsonia*

9. Stem long, over 15 cm long .... *Aerides*

1. Terrestrial or saprophytic plants 10

10. Lip not spurred, often saccate at the base; sac never projecting beyond the lateral sepals 11

11. Leaves and flowers appearing together .... *Malaxis* (P.P.)

11. Leaves and flowers not appearing together 12

12. Plants with pseudobulbs .... *Nervilea*

12. Plants without pseudobulbs, rhizomatous .... *Cheirostylis*

10. Lip spurred; spur projecting beyond lateral sepals 13

13. Leaves plicate or absent .... *Eulophia*

13. Leaves not plicate; anthers immovably afixed to column by a broad base 14

14. Flowers ± 7.5 cm across, stigmatic surface flat, almost confluent .... *Platanthera*

14. Flowers less than 3 cm across, stigmatic surface not flat, separate 15

15. Ovary and capsules ± erect and parallel to peduncle, not spreading at an angle to it; stigmatic surfaces in form of small swellings on edge of lip .... *Peristylus*

15. Ovary and capsules widely spreading at an angle to peduncle; Stigmatic lobes standing out as stalked appendages .... *Habenaria*

Aerides Lour.

1. Midlobe of lip linear-oblong, about 7 mm long, white or pale lilac; spur nearly equalling the lip .... *A. ringens*
1. Midlobe of lip broadly obovate or obovate deltoid over 14 mm. long, deep pink-mauve; spur as half as long as lip. 2
    2. Sepals and petals spotted; lateral lobes of lip minute, rounded; mid-lobe 12-14 mm long .... *A. maculosum*
    2. Sepals and petals not spotted; lateral lobes of lip 7-9 mm long, narrowly oblong; midlobe 22-22 mm long ...... *A. crispum*

1. **Aerides crispum** Lindl., Gen. Sp. Orch. 239, 1833; Birdwood, 27; Cooke, T. 2: 700; Puri & Mahajan, 133; Sant. & Kapadia, 123.

A. lindleyana Wight, Icon. t. 1677, 1851; Dalz. & Gibs, 265; Cooke, 2:652 (3: 204); Lisboa, 224.

A rare epiphytic orchid at Mahabaleshwar. The reason for its near extinction in Mahabaleshwar is its showy and fragrant flowers. There is one teratological specimen of this species in Blatter Herbarium which has produced leaves at the end of the spike.

FLOWERS: May-June; FRUITS: July onwards.

VERNACULAR NAMES: Ruk Shing, Pan Shing.

DISTRIBUTION AT MAHABALESHWAR: Chinaman's falls, Yenna lake, Koyna Valley.

2. **Aerides maculosum** Lindl. in Bot. Reg. t. 58, 1845, Cooke, 652; Birdwood, 27; Nairne 325; Cooke, T. 2: 699 (3: 203); Santapau & Kapadia, 122.

Saccolobium speciosum Wight, Icon. tt. 1674-5, 1851.

A common epiphytic orchid in open deciduous forests. Very often the velamen roots are associated with tubercled swelling.

FLOWERS: May-June; FRUITS: July onwards.

DISTRIBUTION AT MAHABALESHWAR: Kelghar Ghat.

3. **Aerides ringens** Fisher, in Kew Bull. 1928: 284, 1928; Blatter & McCann, 490, 1932; Santapau & Kapadia, 119.

A. radicosum A. Rich. in Ann. Sc. Nat. (ser. 2) 15: 65, f. 1C, 1841; Cooke, 2: 700 (3: 204); Puri & Mahajan, 134.

S. paniculatus Wt. Ic. 5(1): 9, t. 1676, 1851.

This species is given here on the authority of woodrow only. There are no specimens available from Mahabaleshwar in any of the herbaria.

FLOWERS: March-July.

FRUITS: July onwards.

Bulbophyllum Thouars.

1. **Bulbophyllum fimbriatum** (Lindl.) Reichb. f. in Walp. Ann. 6: 260, 1861; Blatter & McCann, 35: 265, 1931.

Cirrhopetalum fimbriatum Lindl. in Bot. Reg. Misc. 72, 1839; Wight, Icon. t. 1665; Cooke, 652 & 2: 686 (3: 188); Birdwood, 27; Santapau & Kapadia, 197-8.

C. wallichii Graham, Cat. Bomb. Plants, 205, 1839 (non Lindl.).

This species is found in open deciduous forests. The flowers give an unpleasant odour. Specimens of this species in Blatter herbarium differ from North Kanara specimens in having slightly larger petals.

FLOWERS: March-April;

LEAVES: June-November.

DISTRIBUTION AT MAHABALESHWAR: Rotunda Ghat, Below Bombay point, Koyna Valley.

Cheirostylis Blume

1. **Cheirostylis flabellata** Wt. Icon. 5(1): 16, t. 1727, 1852 (*Monochilus flabellatum* in Plate). FBI 6: 105.

A rare epiphytic species known from a single collection from Lingmala (P. V. Bole - 2244).

FLOWERS: November.

Cymbidium Sw.

1. **Cymbidium aloifolium** Sw., in Nov. Act. Sc. Upsal. 6: 73, 1799; Graham, 203; Nairne, 325.

This species has been reported from Mahabaleshwar by John Graham (1839). We have not seen any specimen of this species.

Dendrobium Sw.

1. Rhizome distinct, creeping; leaf 1, from top of pseudobulb; flowers 1-2 borne on the top of the pseudobulb .... *D. macraei*
1. Rhizome not distinct; leaves several, bifarious; flowers many in racemes or in pairs, rarely solitary 2
    2. Stems usually tufted forming small ovoid pseudobulbs, rarely elongate; flowers in slender racemes, rarely solitary 3
        3. Stems long, much branched; lip undivided or obscurely 3-lobed .... *D. herbaceum*
        3. Stem simple often reduced to small pseudobulbs; lip distinctly 3-lobed 4
    4. Small plants with crowded, ovoid pseudobulbs; petals not broader than dorsal sepal 5
        5. Lip pink with deep purple veins, irregularly crenulate, broader across later lobes than the midlobe; small, irregularly crenulate, truncate or subretuse .... *D. microbulbon*
        5. Lip pale yellow or yellow-green, ± suffused with pink, equal to or narrower than midlobe; midlobe of lip suborbicular, with two rows of stiff, glandular hairs on margin, rounded or subemarginate .... *D. nanum*
    4. Larger plants with elongate pseudobulbs (rarely uninodal); petals much broader than the dorsal sepal 6
        6. Flowers cream-coloured; midlobe of lip somewhat quadrate-rounded .... *D. ovatum*
        6. Flowers pure white or tinged with pink; midlobe of lip broadly ovate, or ovate-oblong or rarely sub-flabellate .... *D. barbatulum*
    2. Stems elongate, clavate or nodose; flowers in lateral pairs or fascicles, rarely solitary 7
    7. Flowers subregular; mentum absent; column without a foot .... *D. lawianum*
    7. Flowers zygomorphic; mentum distinct; column with a distinct foot 8
        8. Flowers pale watery-green, lateral lobes broad, flat .... *D. aqueum*
        8. Flowers white or suffused with pale rose; lateral lobes forming a small pouch at the base .... *D. crepidatum*

1. **Dendrobium aqueum** Lindl., in Bot. Reg. Misc. 6, t. 54, 1843; Cooke, T. 2: 653 (3: 187); Santapau & Kapadia, 99.

D. album Wight, Icon. 5(1): 6, t. 1645, 1851.

A fairly common epiphytic species, especially on *Terminalia chebula.*

FLOWERS: September-October.

FRUITS: December-May.

DISTRIBUTION: Lingmala Fall, Below Bombay Point, Rotunda Ghat, Fitzgerald Ghat.

2. **Dendrobium barbatulum** Lindl., Gen. Sp. Orch. 84, 1830; Dalz. & Gibs. 261; Nairne 322; Cooke, T. 652 (3: 184); Lisboa, 224; Birdwood, 27; Gammie, J. Bombay nat. Hist. Soc. 17: 31, t. 2, 1906; Cooke, T. 2: 682; Puri & Mahajan, 133 (herbatulum); Santapau & Kapadia, 93-4.

Common and abundant orchid all over in deciduous forests.

FLOWERS: January-May.

FRUITS: March-July.

DISTRIBUTION: Chakdev, Lingmala, Fitzgerald Ghat.

3. **Dendrobium crepidatum** Lindl., in Paxton, Fl. Gard. 1: 63, f. 45, 1850-51; Birdwood, 27; Gammie, 33; Cooke, 2: 683 (3: 185); Puri & Mahajan, 133; Santapau & Kapadia, 101-2.

Flowering specimen of this species has not been collected after its report by Dr. T. Cooke, from Mahabaleshwar. It is included here on Cooke's authority. Reported only from Koyna Valley.

VERN. NAMES: Bechu, Nangli.

4. **Dendrobium herbaceum** Lindl. Bot. Misc. 69, 1840; Nairne 323; Cooke, 2: 682; (3: 184); Puri & Mahajan, 133; Santapau & Kapadia, 82-4.

D. ramosissimum Wight, Icon 5(1) 6, t. 1648; Cooke, 2: 682 (3: 184); Puri & Mahajan, 133; Santapau & Kapadia, 82-4.

Quite common epiphyte in deciduous forests. This orchid comes in bloom soon after the monsoon is over.

Collected from Lingmala, Rotunda Ghat, Pratapsingh Park.

FLOWERS: September-October.

FRUITS: October onwards.

5. **Dendrobium lawianum** Lindl., in Journ. Linn. Soc. 3: 10, 1859 (lawanum); Cooke, 2: 652 (3: 186); Santapau & Kapadia, 102-105, t. 25.

Dendrobium roseum Dalz., Hook. Kew Journ. 4: 291, 1852.

This species is included here on authority of T. Cooke (1885): There is no good flowering specimen of this species in any of the herbaria consulted. There is one sterile specimen collected by T. Cooke, deposited in Blatter Herbarium. This sterile specimen resembles very much to *D. aqueum* Lindl.

6. **Dendrobium nanum** Hook. f., in Hook. Icon. Pl. t. 1853, 1889; FBI 5: 717, 1890; Seidenfaden, in Mathew, Fl. Tamilnadu Karnatek, 1587-8, 1983.

D. mabelae Gammie, in J. Bombay nat. Hist. Soc. 16: 567, 1905; Cooke 2: 681 (3: 183); Blatter & McCann, 262; Santapau & Kapadia 89-91, t. 20.

A perennial epiphyte with yellowish green pseudobulbs. Membranaceous sheeth of pseudobulbs forms network of fibres after drying of leaves. Collected from Lingmala, Fitzgerald Ghat, and Rotunda Ghat.

FLOWERS: July-September.

FRUITS: September onwards.

7. **Dendrobium macraei** Lindl., Gen. Sp. Orch. 75, 1830; Cooke, T. 652; Birdwood 27; Cooke, 2: 680 (3: 182); Santapau & Kapadia, 79-81, t. 16.

D. nodosum Dalz., in Hook. Journ. Bot. 4: 292, 1852.

Very remarkable species with distinct and creeping rhizome. Leaves remain persistent throughout the year. This species is included here on the authority of T. Cooke and Woodrow. It is reported by them from Koyna Valley.

FLOWERS: July-August.

8. **Dendrobium microbulbon** Rich. in Ann. Soc. Nat. (ser. 2), 15: 19, t. 8, 1841; Birdwood, 22: Nairne 322; Cooke, 2: 681 (3: 183); Puri & Mahajan, 133; Santapau & Kapadia, 87-8, t. 18.

D. humile Wight, Icon. t. 1643, 1852; Cooke, 652.

A tiny pseudobulbous epiphytic orchid. Leaves caducous. Flowers white with faint fragrance appear in the beginning of the monsoon.

FLOWERS: July-October.

FRUITS: January-May.

DISTRIBUTION: Chinaman's Falls, Lodwick point, Mahabaleshwar town.

9. **Dendrobium ovatum** (Willd.) Kranz., in Planzenr. 45: 71, 1910; Puri & Mahajan, 133; Santapau & Kapadia, 91-3, t. 21.

Cymbidium ovatum Willd. Sp. Pl. 4: 101, 1805.

D. chlorops Lindl., in Bot. Reg. Misc. 44, 1844; Birdwood, 26; Cooke, 2: 682 (3: 184).

D. barbatulum Wight, Icon. t. 910, 1843 (non Lindl.).

This species is usually found in open deciduous forests, as an epiphyte. It is reported from Mahabaleshwar by T. Cooke. We have not seen any reliable specimen in any of the herbaria consulted.

FLOWERS: September-January.

FRUITS: February-March.

10. **Dendrobium macrostachyum** Lindl. Gen. Sp. Orch. 78, 1830; Wight, Icon. t. 1647, 1851; Cooke, 2: 683 (3: 185); Santapau & Kapadia, 96-8.

A pendulous epiphyte with sweet scented flowers which are racemose, pale green first

This species has been collected by T. Cooke from Koyna Valley.

FLOWERS: May-June.

FRUITS: June-December.

11. **Dendrobium pierardii** Roxb., in Hook. Exot. Flor. t. 9, 1828 et Fl. Ind. 3: 482, 1832; Graham, 203; FBI, 5: 738-9; Birdwood, 27; Cooke, 2: 685 (3: 187).

The species has been recorded by Birdwood. But Santapau & Kapadia have not included this species among Bombay Orchids.

Eria Lindl. (nom. cons.)

1. Flowers 20-30 mm long, solitary...... *E. reticosa*
1. Flowers under 12 mm long, in racemes........ 2
    2. Pseudobulbs conical-ovoid; scapes shorter or equalling the leaves; pedicels and ovary puberulous .... *E. mysorensis*
    2. Pseudobulbs discoid; scapes longer than the leaves; pedicels and ovary glabrous........ 3
        3. Scapes usually without leaves, zigzag, 1-4 cm. long; flowers greenish white .... *E. exilis*
        3. Scape always with leaves, straight, 3-9 cm long, flowers pale yellow 4
            4. Flowers secund, lip without callosites at the base .... *E. dalzellii*
            4. Flowers not secund; lip with two callosites at the base .... *E. microchilos*

1. **Eria dalzellii** (Hook.) Lindl. in J. Linn. Soc. 3: 47, 1858 (nom. et syn., non descr.); Birdwood, 27; Cooke 2: 651 (3: 193); Santapau et Kapadia, 152-3.

Dendrobium dalzellii Hook. J. Bot. 4: 292, 1852.

More or less robust herbs with stout peduncles. Floral bracts up to 3 times longer than the ovary. Margins of sepals and petals with capitate glands. Lip without callosites at the base.

FLOWERS: July-August.

FRUITS: August-October.

DISTRIBUTION: Lingmala, Fitzgerald Ghat, Koina Valley.

2. **Eria exilis** Hook. f. in Fl. Brit. India, 5: 788, 1890; Hook. f. Ic. Pl. t. 2074, 1891; Santapau & Kapadia, 150-151.

E. minima Blatt. & McCann, in J. Bombay nat. Hist. Soc. 35: 274, f. 2, 1931.

Minute epiphytes with pseudobulbs 3-12 mm across. Leaves sessile appearing usually before the flowers. Petals more or less half as long as sepals; the lip more or less equalling the petals.

FLOWERS: October-December.

FRUITS: October-May.

DISTRIBUTION: Tiger Path, Madhu Kosh, Folkland point, Lodwick point, Chinaman's falls.

3. **Eria microchilos** (Dalz.) Lindl. in J. Linn. Soc. 3: 47, 1858 (nom. et syn., non descr.); Cooke 2: 652 (3: 194); Santapau et Kapadia, 154-6.

Dendrobium microchilos Dalz. in Hook. J. Bot. 3: 345, 1851.

Slender herbs with more or less filiform peduncle. Floral bracts just longer than ovary. Margins of sepals and petals without glands. Lip with 2 callosites at the base.

FLOWERS: July-August.

FRUITS: August-October.

4. **Eria mysorensis** Lindl. in J. Linn. Soc. 3: 54, 1858; Birdwood, 27; Cooke, 2: 652 (3: 194); Santapau & Kapadia, 149.

E. pubescens Wight, Icon. 5(1): 4, 1851, *E. polystachya* Wight, Icon. t. 1634, 1851 (non A. Rich. 1841).

Epiphyte with ± 3 cm long pseudobulbs. Flowers white; lip with purple blotches at the base and apical part yellow. The only specimen of this species near Mahabaleshwar was collected from Koyna Valley.

FLOWERS: July.

5. **Eria reticosa** Wight, Icon. 5(1): 4, t. 1637, 1851; Cooke, 2: 690 (3: 193); Puri & Mahajan, 133; Santapau, 303; Santapau & Kapadia, 146-7, t. 34.

E. uniflora Dalz. in Hook. J. Bot. 111, 1852.

E. bracteata Dalz. & Gibs. Bombay Fl. 262, 1861 (non Lindl. 1859); Cooke, 2: 652 (3: 193); Birdwood, 27.

E. rupestris Blatt. & McCann. in J. Bombay nat. Hist. Soc. 35: 270, f. 6, 1931.

This species is found on perpendicular rocks and tree-trunks in open situations, always directly facing the monsoon showers.

Pseudobulbs discoid with reticulate sheath, which become loose on drying. Leaves appearing along with flowers. Flowers white, variable in size, sweetly and strongly scented.

FLOWERS: June-July.

FRUITS: August-March.

DISTRIBUTION: Fitzgerald Ghat, Lodwick point, Rotunda Ghat, Lingmala.

Eulophia R. Br. (nom. cons.)

1. **Eulophia nuda** Lindl., Gen. Sp. Orch. 180, 1833; Blatter & McCann, 487; Cooke 2: 693 (3: 197); Santapau & Kapadia, 115-6.

E. bicolor Dalz. in Kew J. Bot. 3: 343, 1851.

Cryptopera fusca Wight, Icon. 5(1): 11, t. 1690, 1891.

Very variable plant, in respect to the size and colour of the flowers. This species collected from Ambenali from the foot of Mahabaleshwar, by Blatter & McCann.

FLOWERS: June.

Habenaria Willd.

1. Petals 2-partite 2
  2. Lower segment of petals filiform, less than or upto half as long as the upper ones .... *H. digitata*
  2. Lower segments of petals 2-3 times longer than the upper ones 3
    3. Leaves several, clustered about the middle of the stem .... *H. multicaudata*
    3. Leaves few, radical 4
      4. Leaves 2-5, oblong or oblong-lanceolate, thin, not flat on ground .... *H. rariflora*
      4. Leaves 1-2, ovate to almost orbicular, flat on ground, fleshy, coriaceous .... *H. grandifloriformis*
1. Petals entire 5
  5. Leaves 2, rarely more, flat on ground...... .... *H. crassifolia*
  5. Leaves radical or cauline, not flat on ground 6
    6. Lateral lobes of lip broader than midlobe, obliquely truncate, denticulate at apex 7
      7. Spur shorter than or equalling ovary.. .... *H. panchganensis*
      7. Spur 1½-3 times longer than ovary.... .... *H. plantaginea*
    6. Lateral lobes of lip not broader than midlobe, linear-oblong to linear-filiform .... *H. hayneana*

1. **Habenaria crassifolia** A. Rich., in Ann. Sci. Nat. (ser. 2) 15: 72, t. 3C, 1841; Birdwood, 28; Cooke, 2: 722 (3: 227); Santapau & Kapadia, 22-4; Puri & Mahajan, 134.

Platanthera brachyphylla Lindl. Gen. Sp. Orch. 293, 1835; Wight, Icon., t. 1694, 1853; Lee, 466.

This is a common orchid, found on hill-slopes among grass.

FLOWERS: August-October.

DISTRIBUTION: Petit Road, Lodwick point, Yenna Lake, Lingmala, Fitzgerald Ghat, Chinaman's falls, Wilson point, Dhobi falls.

2. **Habenaria digitata** Lindl. Gen. Sp. Orch. 307, 1835; Cooke, 2: 715 (3: 220); Puri & Mahajan, 134; Santapau, 303; Santapau & Kapadia, 10-12, t. 3, ff. 7-8.

H. trinervia Wight, Icon. t. 1701, 1851; Cooke, 652, 1885.

Common orchid in open grasslands.

FLOWERS: July-October.

FRUITS: August-November.

DISTRIBUTION: Petit Road, Lodwick point, Lingmala, Chinaman's falls, Kate's point, Bobington point, Old Mahabaleshwar, Wilson point.

3. **Habenaria gibsoni** var. **foliosa** (Hook. f.) Santapau & Kapadia, in J. Bombay nat. Hist. Soc. 56: 194, t. 2, f. 6, 1959.

A. foliosa A. Rich. in Ann. Sci. Nat. (ser. 2) 15: 71, t. 3A, 1841; Wight, Icon. t. 1700, 1853; Cooke 2: 716 (3: 221).

H. digitata var. *foliosa* Hook. f. in FBI. 6: 135, 1890; Cooke, 2: 716 (3: 220).

H. spencei Blatt. & McCann, J. Bombay nat. Hist. Soc. 36: 17, t. 3, 1932.

A rare species of which only two specimens are known from Mahabaleshwar.

Santapau & Kapadia ascribe the authority of this variety to Achille Richard, but actually the species was reduced to varietal rank by J. D. Hooker in Flora of British India. This taxon is known from Mahabaleshwar from a single collection.

FLOWERS: September.

4. **Habenaria grandifloriformis** Blatter et McCann, J. Bombay nat. Hist. Soc. 36: 17, 1932; Santapau & Kapadia, 17-19.

H. grandiflora Lindl. ex Dalz. & Gibs., Bombay Fl. 267, 1861; (non Torr. ex Beck. 1823); Birdwood, 27; Cooke, 2: 716 (3: 221); Santapau, 400, 1962 & 303, 1963; Puri & Mahajan, 134.

H. rotundifolia Lindl. Gen. Sp. Orch. 306, 1835. (non A. Rich. 1823).

H. grandifloriformis var. *aequiloba* Blatter et McCann, ibid. 18, 1832.

A common orchid in open grasslands among short grasses. It is one of the first species to come into flowers at the beginning of the monsoon.

FLOWERS: June-July.

DISTRIBUTION: Wilson point, Kate's point.

5. **Habenaria heyneana** Lindl. Gen. Sp. Orchid. 320, 1835; Wight Icon. t. 923; Cooke, 2: 199 (3: 225); Santapau, 400, 1962 & 303, 1963; Santapau & Kapadia, 32-3. *H. candida* Dalz., in Hook. J. Bot. 2: 262, 1850.

H. cerea Blatter & McCann. J. Bombay nat. Hist. Soc. 36: 21, t. 6, 1932.

H. cerea var. *polyantha* Blatter & McCann, ibid. 22, 1932.

H. subpubens A. Rich., Ann. Sci. Nat. (ser. 2) 15: 75, t. 4C, 1841; Birdwood, 28; Nairne 331.

A rather variable orchid growing abundantly in rocky plateaus. Flowers are white or cream coloured which turn yellow gradually and finally black on drying. It is a common orchid on hill-slopes among grass.

FLOWERS: August-November.

DISTRIBUTION: Petit Road, Kate's point, Sindola.

6. **Habenaria multicaudata** Sedgwick, in Rec. Bot. Surv. India, 6: 352, 1919; Blatter & McCann, 16; Santapau & Kapadia, 14-15 t. 6, f. 1.

This species is known from a single collection from Mahabaleshwar and it is not reported from the reorganised State of Maharashtra by earlier collectors.

FLOWERS: September.

7. **Habenaria panchganensis** Santapau & Kapadia, in J. Bombay nat. Hist. Soc. 54: 478, 1957 et Orchid Bombay, 27-8, t. 6, f. 24.

H. variabilis Blatter & McCann, in J. Bombay nat. Hist. Soc. 36: 19-20, tt. 4-5, 1932 (non Ridley, 1886).

This is one of the commonest and most abundant ground orchids at Mahabaleshwar during the monsoon.

FLOWERS: July-September.

DISTRIBUTION: Sindola plateau, Wilson point, Kate's point, Petit Road.

8. **Habenaria plantaginea** Lindl. Gen. Sp. Orch. 323, 1835; Wight, Icon. t. 1710, 1851; Cooke, 2: 718 (3: 224); Birdwood, 28; Santapau, 308; Puri and Mahajan, 134.

This species is found on open slopes of hills either singly or in groups.

FLOWERS: September-November.

DISTRIBUTION: Lodwick point, Ambenali.

9. **Habenaria longecorniculata** Graham, Cat. Bombay Plants, 202, 1839; Santapau & Kapadia, 29-30.

H. longecalcarata A. Rich. in Ann. Sci. Nat. (ser. 2) 15: 71, t. 3B, 1841: Wight, Icon. t. 1925, 1853; Cooke 2: 198 (3: 223); Puri & Mahajan, 134.

H. longecalcarata var. *viridis* Blatter & McCann, J. Bombay nat. Hist. Soc. 36: 20, 1932.

This species is reported here only on the authority of Puri & Mahajan. We have not seen any authentic specimen from Mahabaleshwar although it is quite common at Matheran, Amboli, Poona & Khandala.

FLOWERS: July-September.

FRUITS: October.

SPECIMEN MENTIONED: Puri - 25625 (BSI).

10. **Habenaria rariflora** A. Rich., Ann. Sci. Nat. (ser. 2) 15: 70, t. 20, 1841; Wight, Icon. t. 924; Cooke 2: 776 (3: 221); Santapau & Kapadia, 15-17, t. 3, ff. 9-10.

Rare species among the grasses. Only specimen of this species in Blatter Herbarium (L. J. Sedgwick — 7964) is supposed to have been collected in April, which is otherwise a typical monsoon species.

Malaxis Solander ex 0. Swartz

1. **Malaxis rheedii** Sw. Kongl. Vetansk. Acad. Nya Handl. 21: 235, 1800; Graham, Cat. Bombay Pl. 202, 1839; Nair & Ansari, Taxon 30: 475, 1981.

Malaxis versicolor (Lindl.) Santapau & Kapadia, J. Bombay nat. Hist. Soc. 58: 347, 1961.

Microstylis versicolor Lindl. Gen. Sp. Orch. 21, 1830; Cooke, 2: 678 (3: 179-80); Puri & Mahajan, 133; Santapau, 304.

M. rheedii Wight, Icon. t. 902, 1844-5; Cooke, 652, 1885; Birdwood, 27.

Quite common perennial herb in shady places usually found in rocky grounds.

FLOWERS: July-November.

DISTRIBUTION: Yenna lake, Lingmala, Fitzgerald Ghat, Goulani Point.

Nervilia Comm. ex Gaud. (nom. cons.)

1. **Nervilia prainiana** (King & Prantl.) Seidenf. Dansk. Bot. Ark. 32(2): 149, 1978.

Nervilia crispata auct. (non(Bl.) Schltr. 1911); Rao, Bull. Bot. Surv. Ind. 5: 63, t. 1, 1963.

Pogonia prainiana King & Prantl. J. Asiat. Soc. Bengal, Pt. 2, Nat. Hist. 65: 129, 1896.

N. monantha Blatter & McCann, J. Bombay nat. Hist. Soc. 35: 724, 1932; Santapau & Kapadia 130.

A rare species in shady places near Lingmala. Only known from a single collection (M. R. Almeida — 2236).

FLOWERS: August-September.

Oberonia Lindl. (non. cons.)

1. Flowers in distinct verticals, not imbricating; pedicels more than 2 mm. long.... *O. recurva* var. *lingmalensis*
1. Flowers imbricating; pedicels short (0.75-1.5 mm. long) .... *O. recurva* var. *recurva*

1. **Oberonia recurva** Lindl. in Bot. Reg. Misc. 8, 1839; Cooke, 2: 676 (3: 176); Birdwood, 27; Cooke 2: 676; Puri & Mahajan, 133; Santapau & Kapadia, 61-2.

Rare epiphytic orchid, very variable with regards to its shape and size of the floral parts.

FLOWERS: November-February.

FRUITS: December-July.

2. **Oberonia recurva** var. **lingmalensis** (Blatter & McCann) Santapau & Kapadia, J. Bombay nat. Hist. Soc. 57: 259, 1960; Santapau & Kapadia, 64.

O. lingmalensis Blatter & McCann, J. Bombay nat. Hist. Soc. 35: 255, 1931.

Common epiphytic orchid all over Mahabaleshwar.

FLOWERS: July-December.

DISTRIBUTION: Yenna Lake, Lingmala, Wilson point, Bhilar estate, Kate's point, Mahabaleshwar Bazar.

Peristylus Blume

1. Leaves sessile, narrowly lanceolate; Lateral sepals linear; lateral lobes of lip subulate, or narrowly linear oblong, spreading, about twice as long as the midlobe; spur scarcely clavate at the apex.... .... *P. densus*
1. Leaves tapered at the base, broadly obovate-elliptic; lateral sepals broad; lobes of lip subequal; linear-oblong, rounded; spur inflated at the apex 2

2. Spur equalling or exceeding the sepals; flowers yellow .... *P. stocksii*
2. Spur shorter than the sepals; flowers green.. .... *P. aristatus*

1. **Peristylus densus** (Lindl.) Santapau & Kapadia, Orchids of Bombay, 46-8, t. 9 A-B, 1966.

Coeloglossum densum Lindl. Gen. Sp. Orch. 302, 1835. *Habenaria peristyloides* Wight, Icon. t. 1702, 1851.

H. stenostachya Benth. Fl. Hong Kong, 362, 1861; Birdwood, 28.

P. xanthochlorus Blatt. & McCann, J. Bombay nat. Hist. Soc. 35: 734, 1932.

Rare orchid in partially shaded places along forest margins.

FLOWERS: August-October.

2. **Peristylus aristatus** Lindl. ex Gamble, Fl. Pres. Madras 1474, 1928; Jorapur & Garg, Ind. J. Forestry, 3(2): 174-5, 1980.

H. aristatus Hook. f., in Fl. Brit. Ind. 6: 156, 1890.

This species has been reported from Babington point on way to Robber's Cave in open cut forest. Only specimen of this species is in Herbarium of Botany Department of Karnataka University.

FLOWERS: August.

3. **Peristylus stocksii** (Hook. f.) Kranz. Orchid, Gen. Spec. 1: 51, 1898; Cooke, 2: 710; Santapau & Kapadia, 48-9, t. 9 C-D!.

Habenaria stocksii Hook. f., Fl. Brit. Ind. 6: 158, 1890.

Common orchid in the undergrowth of forests.

FLOWERS: July-September.

FRUITS: August-October.

Platanthera L. C. Rich.

1. **Platanthera susannae** (Linn.) Lindl. Gen. Sp. Orch. 295, 1835; Wight, Icon. t. 920, 1844-5; Lee, 466; Nairne 329-30; Cooke, 2: 713; Puri & Mahajan 134; Santapau 134; Santapau & Kapadia, 42-5, t. 7.

Orchis susannae Linn. Sp. Pl. 939, 1753.

Habenaria susannae R. Br. Prodr. 312, 1810; Birdwood, 24.

H. gigantea Don, Prodr. Fl. Nep. 24, 1825; Graham, 201.

Rare species among the grasses and extremely endangered due to enthusiastic collectors, for its large fragrant flowers.

OCCURRENCE: Lingmala.

FLOWERS: September-October.

FRUITS: October-December.

Rhynchostylis Bl.

1. **Rhynchostylis retusa** (Linn.) Blume, Bijdr. 286, t. 49, 1825; Santapau, 304 1963; Santapau & Kapadia, 211-12.

Epidendrum retusum Linn. Sp. Pl. 953, 1753. *Aerides retusum* Sw. in Schrad. J. 2: 233, 1799; Graham, 204.

This species is reported from a single collection from Mahabaleshwar (H. Santapau - 13134 B). We have not seen this species at Mahabaleshwar and Rev. Fr. Santapau's above mentioned specimen is not located in Blatter Herbarium.

Thunia Reichb. f.

1. **Thunia venosa** Rolfe, in Orchid. Rev. 13: 206, 1905; Cooke, 2: 692; Puri & Mahajan, 133; Santapau & Kapadia, 184-6, t. 43.

There is only one herbarium specimen at Calcutta (CNH), collected by Cartensen. We have not seen it in the area under study.

FLOWERS: July. FRUITS: March.

Vanda R. Br.

1. **Vanda testacea** (Lindl.) Reichb. f., Gard. Chron. 2: 166, 1877; Santapau & Kapadia, 219-220.

Aerides testaceum Lindl. Gen. Sp. Orch. 238, 1833.

V. spathulata Graham, Cat. Bombay Pl. 204, 1839 (non Spr. 1826).

V. parviflora Lindl., Bot. Reg. 30: Misc. 45, 1844; Wight, Icon. t. 1669, 1851; Cooke, 2: 703; Puri & Mahajan, 134.

Rare orchid in Koyna Valley, below Mahabaleshwar. We have not seen this species on the plateau.

FLOWERS: May-June; FRUITS: July onwards.

ZINGIBERACEAE

1. Lateral staminodes broad 2
    2. Connectives not spurred at the base; corolla-tube long, slender 3
        3. Stigma turbinate .... *Hitchenia*
        3. Stigma subglobose .... *Hedychium*
    2. Connectives spurred at the base; corolla-tube funnel-shaped .... *Curcuma*
1. Lateral staminodes small, obtuse, narrow....... .... *Zingiber*

Curcuma Linn.

1. Flowers appearing with the leaves; bracts of coma with purple edges only .... *C. pseudomontana*
1. Flowers appearing before leaves on a separate stalk; bracts of the coma entirely purple or crimson .... *C. zerumbet*

1. **Curcuma pseudomontana** Graham, Cat. Pl. Bombay 210, 1839; Dalz. & Gibs. 275; Cooke, 2: 730 (3: 236).

C. ranadei Prain, in Journ. Bombay nat. Hist. Soc. 11: 463, 1898.

C. montana Baker, in Hook. f., Fl. Brit. India 6: 214, 1892 (non Rosc., 1828); Birdwood, 28, 1897.

Quite common rhizomatous herb in open forests among undergrowth.

FLOWERS: September-October.

LOCAL NAME: Ram Haldi.

2. **Curcuma zerumbet** Roxb., in Asiat. Res. 11: 333, 1810; Graham, 209.

C. zedoaria Rosc., Monandr. Pl. t. 109, 1828; FBI 6: 210; Birdwood, 28, 1897; Cooke, 2: 732 (3: 238).

Cultivated in private gardens for tubers which are used in medicines as well as making red powder which is used during Holi festival.

FLOWERS: July-September.

LOCAL NAME: Kachora.

Hitchenia Wall.

1. **Hitchenia caulina** (Graham) Baker, in Hook. f., Fl. Brit. India 6: 224, 1890; Birdwood, 28, 1897; Nairne 337; Cooke, 2: 728 (3: 233); Santapau, 398, 1962 & 311, 1963; Puri & Mahajan, 134, 1960.

Curcuma caulina Graham, Cat. Bombay Pl. 210, 1839; Dalz. & Gibs. 275; Lisboa, in Journ. Bombay nat. Hist. Soc. 2: 140, t. opp. p. 140, 1889; Lee 466, 1885; Cooke, 651, 1885.

One of the common and abundant plants of Mahabaleshwar, in monsoon. It is found all over in open as well as in partially shaded places at Lingmala, Wilson point, Kate's point, Babington point, Fitzgerald ghat, Petit road, Lodwick point, Madhu kosh, etc. Tubers of this plant are collected for edible starch. There are two forms commonly met at Mahabaleshwar; one with white bracts and other with purple. Flowers in one form are white whereas in the second form they are pink in colour. Roots bear terminal tubers.

FLOWERS: July-September.

LOCAL NAMES: Chowar, Chavar, Araroot.

Hedychium Koenig

1. **Hedychium coronarium** Koenig, in Retz. Obs. Bot. Fasc. 3: 73, 1783; Graham, 205; Dalz. & Gibs. suppl. 86; Wight, Icon. t. 2010, 1853; Bot. Mag. t. 708, 1803; FBI 6: 225; Birdwood, 28, 1897; Cooke, 2: 728 (3: 234); Puri & Mahajan, 134, 1960.

This species has been reported to occur near Lingmala on sides of Yenna river. We have not been able to locate it in wild state, however it is quite common in cultivation at Mahabaleshwar.

FLOWERS: Throughout the year.

LOCAL NAMES: Sontaka, Gulabchampa.

2. **Hedychium coronarium** Koeng. var. **flavum** (Roxb.) J. G. Baker, in Fl. Brit. Ind. 6: 226, 1892; Birdwood, 28, 1897.

H. flavum Roxb. Fl. Ind. 1: 12, 1824; Bot. Mag. t. 3039, 1831.

This variety with fragrant bright yellow flowers has been reported by Birdwood, on Lisboa's authority. According to him this species comes in blooms immediately after the first rains.

Zingiber Boehm.

1. **Zingiber neesanum** (Graham) Ramamurthy, in Fl. Hassan Dist. 769, 1976. *Alpinia neesana* Graham, Cat. Pl. Bombay 207, 1839.

Z. macrostachyum Dalz. in Kew Journ. Bot. 4: 342, 1852; Dalz. & Gibs. 273; FBI 6: 247; Lee, 466, 1885; Cooke, 651 & 2: 735 (3: 241); Birdwood 28; Puri & Mahajan, 134; Santapau, 400, 1962 & 311, 1963.

Rhizomatous perennial found all over along forest margins as well as in dense shady places among undergrowth. Common at Kate's point, Lingmala, Petit road, Kelghar ghat. Nakinda village, Fitzgerald ghat, and near Yenna lake. Spikes and bracts of the plant are orange-red in colour and develop laterally to the main stem.

FLOWERS: July-August. LOCAL NAME: Nisan.

CANNACEAE

Canna Linn.

1. **Canna indica** Linn. Sp. Pl. 1, 1753; Graham, Cat. 211; Dalz. & Gibs. suppl. 88; FBI 6: 260; Cooke, 2: 744 (3: 251).

Common cultivated ornamental in gardens. Flowers scarlet in colour.

FLOWERS: Throughout the year.

LOCAL NAME: Dev-kel.

MUSACEAE

1. Leaves distichous .... *Ravenala*
1. Leaves in whorls 2
2. Stems dilated at base; fruits with seeds....*Ensete*
2. Stems not dilated at base; fruits seedless....*Musa*

Ensete Bruce

1. **Ensete superbum** (Roxb.) Cheesman, in Kew Bull. 1947: 100, 1948; Santapau, 298, 1963.

Musa superba Roxb., Fl. Ind. 2: 489. 1824; Wight, Icon. tt. 2017-18, 1853; Dalz. & Gibs. 272; Birdwood, 28, 1897; Cooke, 2: 740-41 (3: 247). *M. textilis* Graham, Cat. Bombay Pl. 213. 1839.

Quite common tree-like monocarpic herbs, found on inaccessible cliffs and on hill-slopes along ghat areas. Fruits develop seeds and are not eaten by man, but are eaten by monkeys. Young inflorescences are used as vegetable.

FLOWERS: Throughout the year.

LOCAL NAMES: Ran-kel, Chavan-kel. Chowani, Chawai.

Musa Linn.

1. **Musa paradisica** Linn. Sp. Pl. 1043, 1753; Cooke, 2: 742 (3: 249).

Well known Banana plant cultivated for its fruits, in private gardens.

FLOWERS: Throughout the year.

LOCAL NAME: Kel.

Ravenala Adans.

1. **Ravenala madagascarensis** Sonn. Voy. 3(5): 244, 1782; FBI 6: 198; Cooke, 2: 744 (3: 250).

Urania speciosa Willd., Sp. Pl. 2: 7, 1799; Graham, 213; Dalz. & Gibs. suppl. 89.

Rarely cultivated in gardens as an ornamental plant.

LOCAL NAME: Traveller's tree.

HAEMODORACEAE

Ophiopogon Ker-Gawler

1. **Ophiopogon indicus** Wight, Icon. 6: 26, t. 2050, 1853.

O. intermedius D. Don var. *pauciflora* Hook. f., Flora Brit. India 6: 269, 1892; Cooke, 2: 745 (3: 252).

O. intermedius Trim. Fl. Ceylon 4: 267; 1885 (non Don, 1825); Birdwood, 28; Woodrow, in J. Bombay nat. Hist. Soc. 12: 521, 1899.

Chlorophytum laxum sensu Santapau, 299, 1963 (non R. Br. 1810).

Quite common herb in shady places near Chinaman's fall, Lodwick point, Tiger's path, Dhobi's falls and on Lingmala flats. Flowers are white and are borne in pairs in each bract in a terminal raceme. All the specimens in the Blatter Herbarium were identified as *Chlorophytum laxum.* Rev. Fr. Santapau's record of *C. laxum* from Mahabaleshwar is also constituted on material belonging to this species.

FLOWERS: Throughout the year.

Agaveceae

1. Flowers over 10 cm. long; perianth lobes erect .... *Agave*

1. Flowers less than 6 cm long; perianth-lobes spreading .... *Furcraea*

Agave Linn.

1. **Agave vivipara** Linn. Sp. Pl. 323, 1753. Wight, Icon. 6: 18, t. 2024, 1853; Birdwood, 28, 1897.

A. cantala Dalz. & Gibs. Bombay Fl. suppl. 93, 1861 (non Roxb., 1832); Lisboa 224.

A. wightii Drumond & Prain, in Agric. Ledger 7: 91, 1906; Cooke, 2: 753 (3: 261).

Aloe americana Roxb., Fl. Ind. 2: 167, 1832 (non *Agave americana* Linn. 1753).

Rarely planted as a hedge plant at Mahabaleshwar.

LOCAL NAMES: Chota guial, Guital.

Furcraea Vent.

1. **Furcraea foetida** (Linn.) Howorth, Syn. Pl. Succ. 73, 1812; Baker & Bakh., Fl. Jav. 3: 165, 1968.

Agave foetida Linn. Sp. Pl. 323, 1753.

F. gigantea Ventenat, Bull. Soc. Philom. Paris 1: 65, 1793.

There are few plants of this species planted near Wilson point and near Bhilar.

FLOWERS: October.

Amaryllidaceae

1. Filaments are attached to the perianth-lobes, but not connate. .... *Crinum*

1. Filaments united towards their bases by an intervening petaloid membrane .... *Pancratium*

Crinum Linn.

1. Perianth erect, salver shaped 2

  2. Perianth lobes linear 3

    3. Leaves 7-10 cm wide; umbels 15-20 flowered .... *C. asiaticum*

    3. Leaves 1.5-2 cm wide; umbels 6-12 flowered .... *C. defixum*

  2. Perianth funnel-shaped .... *C. woodrowii*

1. Perianth funnel-shaped 4

  4. Style longer than the filaments; stamens declinate .... *C. latifolium*

  4. Style shorter than the filaments; stamens not declinate .... *C. brachynema*

1. **Crinum asiaticum** Linn., Sp. Pl. 292, 1753; Graham, 215; Dalz. & Gibs. 275; Cooke, 2: 749 (3: 258), 1885; Birdwood, 28; Curtis, Bot. Mag. t. 1073, 1807.

C. toxicarium Roxb. Fl. Ind. 2: 134, 1832; Graham, 216; Wight, Icon. tt. 2021-22, 1853.

Commonly cultivated species in gardens. Very prominent species due to its large cylindric stem-like neck.

FLOWERS: June-July. LOCAL NAME: Nagdaun.

2. **Crinum brachynema** Herbert, in Bot. Reg. Misc. 36, 1842; Cooke, 651, 1885; Woodrow 28; FBI 6: 284; Cooke, 2: 751 (3: 258); Lisboa 224; Puri & Mahajan, 134.

Quite common species in open forests. Naked scapes appear just before the monsoon.

FLOWERS: May.

3. **Crinum defixum** Ker-Gawler, Journ. Sci. & Arts 3: 105, 1817; FBI 6: 281; Curtis, Bot. Mag. t. 2208, 1818; Cooke, 2: 749 (3: 257).

C. roxburghii Dalz. & Gibs. Bombay Fl. 275, 1861; Lee, 466.

C. asiaticum Roxb., Fl. Ind. 2 : 127, 1832: (non Linn. 1753); Cooke, 651, 1885; Birdwood, 28.

Common bulbous plant on Lingmala plateau and near Yenna lake.

FLOWERS: August-September.

4. **Crinum latifolium** Linn. Sp. Pl. 291, 1753; Graham, 216; Wight, Icon tt. 219-20, 1841; FBI 6: 283; Birdwood 28; Cooke, 2: 750 (3: 258).

Rare species along the margins of water courses and in wet grounds.

FLOWERS: May-June.

5. **Crinum woodrowii** Baker, in Bot. Mag. t. 7597, 1898; Cooke, 2: 750 (3: 257).

This species was described from plants grown from bulbs sent by G. M. Woodrow to Kew, from Mahabaleshwar.

FLOWERS: May-June.

Pancratium Linn.

1. **Pancratium triflorum** Roxb., Fl. Ind. 2: 126, 1832; FBI 6: 285; Cooke, 2: 752 (3: 259); Puri & Mahajan, 134.

This species has been reported from Mahabaleshwar by T. Cooke, as well as by Puri & Mahajan. We have not seen any authentic specimen from the area under study.

FLOWERS: May-June.

HYPOXIDACEAE

1. Fruit indehiscent .... *Curculigo*
1. Fruit opening at the top as a circumsessile or 3-valved capsule .... *Hypoxis*

Curculigo Gaertn.

1. **Curculigo orchioides** Gaertn., Fruct. 1: 63, t. 13, 1788; Graham, 215; FBI 6: 277; Birdwood, 28; Cooke, 2: 748 (3: 255); Santapau, 401, 1962 & 297, 1963.

C. malabarica Wight, Icon. 6: 22, t. 2043, f. 1, 1853; Dalz. & Gibs. 276; Birdwood, 28.

C. brivifolia Dryand. in Ait. Hort. Kew (ed. 2), 2, 253, 1811; Graham, 215; Dalz. & Gibs. 276.

Very common herb in open as well as in shady places at Lingmala, Wilson point, Fitzgerald ghat, Kate's point and near Yenna Lake. Very attractive plant with tiny yellow flowers arising from the axils of the radical leaves. It is the first species to sprout in the monsoon and to disappear last. Roots supposed to have medicinal properties and sold in local market under the trade name "Kali Musli".

LOCAL NAME: Kajuri.

Hypoxis Linn.

1. **Hypoxis aurea** Lour., Fl. Cochinch. 200, 1790; FBI 6: 277; Cooke, 2: 747 (3: 254); Puri & Mahajan, 134; Santapau 401, 1962 & 297, 1963.

C. graminifolia Nimmo ex Graham, Cat. Bombay Pl. 215, 1839; Dalz. & Gibs. 276.

Fairly common and abundant herb among the grasses. Cleistogamic flowers and fruits are present on the bulbs. Flowers bright yellow. Fruits with many seeds.

FLOWERS & FRUITS: May-November.

DIOSCOREACEAE

Dioscorea Linn.

1. Stems twining clock-wise; seeds winged........ 2
    2. Leaf-bases acute or rounded; male spike many in fascicles .... *D. oppositifolia*
    2. Leaf-bases cordate; male spikes 1-3 together .... *D. belophylla*
1. Stem twining anti-clock-wise; seeds winged at the base only 3
    3. Leaves simple 4
        4. Stems winged .... *D. sativa*
        4. Stems not winged .... *D. bulbifera*
    3. Leaves 3-5 foliate .... *D. pentaphylla*

1. **Dioscorea belophylla** Voight, Hort. Sub. Calc. 635, 1845; Prain & Burkill, in Ann. Bot. Gard. (Calcutta) 14(2): 348, t. 127, 1938; Santapau, 294, 1963.

D. nummularia var. *belophylla* Prain, Bengal Pl. 2: 1067, 1903.

A rare climber along edges of the forests near Lingmala. All specimens at Blatter Herbarium are sterile.

2. **Dioscorea bulbifera** Linn., Sp. Pl. 1033, 1753; Graham 219; Birdwood 28; Wight, Icon. t. 878, 1844, Cooke 2: 758 (3: 268).

Helmia bulbifera Kunth., Enum. 5: 435, 1850; Dalz. & Gibs. 247.

Rarely cultivated in gardens for the bulbils which are used as vegetables.

FLOWERS: August-September.

LOCAL NAME: Karanda.

3. **Dioscorea oppositifolia** Linn. Sp. Pl. 1033, 1753; Graham 219; FBI 6: 292; Dalz. & Gibs. 247; Wight, Icon. t. 813; Cooke, 2: 758 (3: 266):

Common climber along road-sides and along edges of forests. the flowers are produced in great profusion and in bud condition they are used by local people as a vegetable.

FLOWERS: August-October.

LOCAL NAME: Paspoli.

4. **Dioscorea pentaphylla** Linn., Sp. Pl. 1032, 1753; Graham 218; FBI 6: 281; Dalz. & Gibs. 247; Wight, Icon. t. 814, 1844; Birdwood 28; Cooke, 2: 757 (3: 264); Puri & Mahajan, 134; Santapau, 294, 1963.

D. triphylla Linn. Sp. Pl. 1032, 1753; Graham, 218; Dalz. & Gibs. 247; Cooke 651, 1885.

D. jaquemontii Hook. f., in Fl. Brit. Ind. 6: 290, 1892.

Common climber with white flowers at Fitzgerald ghat, Old Mahabaleshwar, Lingmala, Lodwick point, Madhu Kosh and Dhobi's Falls.

FLOWERS: September-October.

LOCAL NAMES: Shend-Vel, Shendon-Vel.

5. **Dioscorea sativa** Linn. Sp. Pl. 1033, 1753; Graham, 218; Dalz. & Gibs. suppl. 92; Hook. f., in FBI 6: 295, 1892; Birdwood 28.

D. bulbifera Linn. var. *sativa* (Linn.) Prain, Bengal Pl. 1065, 1903; Cooke, 2: 758 (3: 266).

Rarely cultivated in gardens for its edible tubers.

FLOWERS: October.

LOCAL NAMES: Godri (Birdwood), Gorkan (Cooke).

MARANTACEAE

Globba Linn.

1. **Globba bulbifera** Roxb., As. Res. 11: 358, 1810; FBI 6: 206; Cooke, 2: 724-5 (3: 230).

G. marantina Wall. Cat. 6532, 1825 (non Linn., 1753) (nom. nud.); Graham, 211; Dalz. & Gibs. 272; Lee. 466.

This species reported here on authority of Lee.

LILIACEAE

1. Shrubs with perennial stems above ground; fruits berry-like .... *Asparagus*
1. Herbs with annual stems or scapes rising usually from underground perennial root-stock, corm or bulb 2
    2. Underground perennial stem small; root-fibres large, numerous, usually some or all fleshy or tuberous ....*Chlorophytum*
    2. Usually underground stems are large in proportion to the roots 3
        3. Climbing herbs .... *Gloriosa*
        3. Erect herbs 4
            4. Perennial stem a solid corm, covered with brown sheathe; usually stems leafy; flowers solitary or corymbose... .... *Iphigenia*
            4. Perennial stem a tunicated bulb; annual scape simple, naked; leaves radical; flowers racemose 5
                5. Seeds sub-globose .... *Scilla*
                5. Seeds flattened 6
                    6. Perianth campanulate, 6-partite .... *Urginia*
                    6. Perianth cylindric, 6-lobed .... *Dipcadi*

Asparagus Linn.

1. **Asparagus racemosus** Willd. var. **javanica** (Kunth.) Baker, in J. Linn. Soc. London 14:

624, 1874; FBI 6: 316; Cooke, 2: 762 (3: 270); Santapau 298.

A. sarmentosus Graham Cat. Bombay Pl. 221, 1839 (non Linn., 1753). *A. jaquemontii* Baker, l.c. 615, 1874.

Asparagopsis sarmentosa Dalz. & Gibs., Bombay Fl. 246, 1861 (non Kunth., 1850); Cooke, 649, 1885.

Asparagus racemosus sensu Birdwood, J. Bombay nat. Hist. Soc.: 28, 1897 (non Willd. 1850); Puri & Mahajan, 134.

Asparagopsis javanica Kunth., Enum. 5: 100, 1850.

Common deciduous sarmentose shrub, generally springing from the shades of other bushy trees and shrubs. Common along sides of Petit Road and along margins of Yenna Lake. Also common at Kate's point.

FLOWERS: June-September.

LOCAL NAME: Ashwal.

Chlorophytum Ker-Gawler

1. Flowers in densely flowered racemes .... *C. breviscapum*

1. Flowers solitary or two in a raceme .... *C. orchidastrum*

1. **Chlorophytum breviscapum** Dalz. in Kew Journ. Bot. 2: 141, 1850; Dalz. & Gibs. 252; FBI 6: 333; Birdwood 28; Cooke 2: 771 (3: 280).

This species has been reported from Mahabaleshwar by Birdwood. We have not seen any specimen, from the area under study.

LOCAL NAME: Kula (Birdwood).

2. **Chlorophytum orchidastrum** Lindl., in Bot. Reg. t. 813, 1824; FBI 6: 336; Cooke, 2: 771 (3: 282); Birdwood 28.

Anthericum nimmonii Graham, Cat. Bombay. *Chlorophytum nimmonii* (Graham) Dalz. in Kew Journ. Bot. 2: 142, 1850; Dalz. & Gibs. 252.

Phalangium oligospermum Wight, Icon. 6: 21, t. 2038, 1753. *C. glaucum* Dalz. in Kew Journ. Bot. 2: 142, 1850; Dalz. & Gibs. 252; FBI 6: 334; Cooke 2: 772 (3: 281-2); Santapau, 299, 1963.

C. glaucoides Blatter, in J. Proc. Asiat. Soc. Bengal (N.S.) 26(1): 361-2, 1930.

Often gregarious on grassy slopes, usually found on precarious rock-ledges and occasionally among the undergrowth in forests. Root-stock is somewhat curled, having about 20 tubers. Tubers white. Common at Lingmala, Ledwick point, Tiger's path and Chinaman's falls.

FLOWERS: July-October.

Dipcadi Medic.

1. **Dipcadi ursulae** Blatter, Journ. Bombay nat. Hist. Soc. 32(4): 735, 1928.

There are few specimens in Blatter herbarium from Bhilar Estate. All specimens are in fruiting condition and without leaves.

FRUITS: April.

Gloriosa Linn.

1. **Gloriosa superba** Linn. Sp. Pl. 305, 1753; Graham, 221; Wight, Icon. t. 2047, 1853; FBI 6: 358; Cooke 2: 766 (3: 274).

Methonia superba Crantz, Inst. Herb. 474, 1766; Dalz. & Gibs. Bombay Fl. 250, 1861.

Rare climber with apical tendrils, found on lower slopes of hills near Wada and in Koyna Valley.

FLOWERS: August-October.

LOCAL NAMES: Bachnag, Khadyanag.

Iphigenia Kunth.

1. Flowers white or pale yellow; capsule obovoid .... *I. pallida*

1. Flowers deep purple; capsule ellipsoid-oblong... .... *I. indica*

1. Flowers pinkish-purple .... *I. stellata*

1. **Iphigenia indica** (Br.) A. Gray, in Kunth., Enum. 4: 213, 1843; FBI 6: 357; Birdwood 29; Cooke 2: 766 (3: 275); Puri & Mahajan, 134.

Anguillaria indica Br. Prodr. 273, 1810.

This species is reported from Mahabaleshwar by Birdwood. We have not seen any authentic specimen in any herbaria from the locality under study.

FLOWERS: June-July.

LOCAL NAME: Markalli (Cooke).

2. **Iphigenia pallida** Baker, in J. Linn. Soc. 17: 451, 1879; FBI 6: 357; Nairne 349; Cooke, 2: 767 (3: 275-6).

Anguiliaria indica Graham, Cat. Bombay Pl. 222, 1839 (non R. Br. 1810).

This species is reported by Cooke on basis of a herbarium specimen at Kew, without precise authority, collected from Mahabaleshwar.

3. **Iphigenia stellata** Blatter, Journ. Bombay nat. Hist. Soc. 32(4): 734, 1928.

Common herb among grasses in rocky grounds. Abundant at Wilson point, Kate's point and Petit road. Flowers pinkish purple. Seeds of this species contain highest percentage of colchicine among *Iphigenia* Spp.

FLOWERS: June-September.

Scilla Linn.

1. **Scilla hyacinthina** (Roth.) McBride. in Contr. Gray Herb. (N.S.) 56: 14, 1918.

Ledebouria hyacinthina Roth., Nov. Pl. Sp. 195, 1821; Wight, Icon. t. 2040, 1853; Graham 220; Dalz. & Gibs. 251.

L. maculata Dalz., Kew Journ. Bot. 2: 143, 1850; Dalz. & Gibs. 251; Cooke, 651, 1885.

S. indica Baker, in Saund. Refug. Bot. 3; appendix 12, 1870 (non Roxb., 1832); FBI 6: 348; Birdwood, 28; Nairne 349; Cooke, 2: 767 (3: 276); Puri & Mahajan, 134; Santapau 401, 1962 & 299, 1963.

Fairly common bulbous herb in open grasslands during first half of the monsoon. Flowers light-purple. Leaves appear after flowers. Abundant at Wilson point and Lingmala.

FLOWERS: June-July.

Urginia Steinh.

1. **Urginia polyantha** Blatter, Journ. Bombay nat. Hist. Soc. 32(4) 735, 1928.

Rare species among the grasses. Only known from a single collection from Bhilar Estate, on way to Panchgani.

FLOWERS: April.

SMILACACEAE

Smilax Linn.

1. **Smilax zeylanica** Linn. Sp. Pl. 1029, 1753; FBI 6: 309; Santapau, 399, 1962 & 304, 1963.

S. macrophylla Roxb., Fl. Ind. 3: 793, 1832 (non Willd., 1806); FBI 6: 310; Graham 219; Dalz & Gibs. 246; Birdwood 28; Cooke 2: 763 (3: 271-2); Puri & Mahajan, 134.

S. ovalifolia Roxb., Fl. Ind. 3: 794, 1832; Graham 219; Wight, Icon. t. 809, 1844; Dalz. & Gibs. 246; Lee, 466; Cooke 649, 1885.

Woody deciduous climber with small prickles, climbing on tall trees. Fruits globose in umbels in axils of leaves. Leaves 5-nerved. Common along Petit Road, near Chinaman's falls, Ludwick point and Lingmala.

FLOWERS: May.

PONTEDERIACEAE

Pontederia Linn.

1. **Pontederia cordata** Linn. Sp. Pl. 288, 1753; Bot. Mag. t. 1156, Engler, in DC. Monogr. Phan. 4: 532, 1883; Bailey, Man. Cult. Pl. 200, t. 32, 1949.

Aquatic fleshy herb in marshy places, in dense clumps in blue flowers. Possibly an introduced plant.

FLOWERS: May.

COMMELINACEAE

1. Leaf-sheaths inflated .... *Amischophacellus*
1. Leaf-sheaths not inflated 2
    2. Flowers irregular .... *Commelina*

2. Flowers regular 3
    3. Stamens 6, all fertile; cymes scorpoid.. .... *Cyanotis*
    3. Stamens 3 fertile and 3 sterile or sterile stamens absent; cymes panicled .... *Murdannia*

Amischophacellus Rao & Kamathy

1. **Amischophacellus axillaris** (Linn.) Rao & Kamathy, J. Linn. Soc. Bot. 59: 306, 1966.

Commelina axillaris Linn. Sp. Pl. 42, 1753.

Tradescantia axillaris Linn. Mant. Pl. 321, 1771; Graham, 223.

Cyanotis axillaris (Linn.) Roem. & Schult. f., Syst. 7: 1154, 1830; Dalz. & Gibs. 256; FBI 6: 388; Birdwood, 29; Cooke 651, 1885 & 2: 795 (3: 305).

This species is reported here on authority of Birdwood.

FLOWERS: August-October.

Commelina Linn.

1. **Commelina paludosa** Blume, Enum. Pl. Jav. 1: 2, 1825; Rolla & Kamat. in Journ. Bombay nat. Hist. Soc. 59: 60, 1962.

C. obliqua Buch,-Ham. ex Don, Prodr. Fl. Nepal, 45, 1825 (non Vahl, 1806); FBI 6: 372; Cooke 2: 784 (3: 293-4); Santapau, 292, 1963.

C. polyspatha Wight, Icon. 6: 29, t. 2066, 1853.

C. communis sensu Cooke, Gazett. Bombay 651, 1885.

C. hirsuta sensu Santapau, J. Bombay, nat. Hist. Soc. 401, 1962.

Common along the road-sides among the hedges in shady places. This is one of the largest flowered species in the genus.

FLOWERS: August-October.

Cyanotis Don (nom. cons.)

1. Roots bearing fusiform tubers....... *C. tuberosa*
1. Roots fibrous, not tuberous 2
    2. Plants cottony; hairs of filaments of two colours .... *C. fasciculata*
    2. Plants not cottony; hairs of filaments one coloured 3
        3. Seeds trigonous; striate .... *C. cristata*
        3. Seeds truncate at base, not trigonous .... *C. wightii*

1. **Cyanotis cristata** (Linn.) Schult. f., Syst. 7: 1150, 1830; Wight, Icon. t. 2082, 1853; Cooke 2: 794 (3: 304); Puri & Mahajan 135; Santapau 135 & 401, 1962.

Commelina cristata Linn. Sp. Pl. 42, 1753.

This species is reported here on authority of Puri & Mahajan and Santapau. We have not seen any authentic specimen from Mahabaleshwar.

2. **Cyanotis fasciculata** (Heyne ex Roth.) Schultes f., Syst. 7: 1152, 1830; FBI 6: 387; Dalz. & Gibs. 225; Cooke, 2: 787 (3: 303).

C. rosea Wight, Icon t. 2086, 1853.

C. dichotricha Wight, Icon. t. 2088, 1853.

Tradescantia fasciculata Heyne ex Roth Nov. Pl. Sp. 189, 1821.

C. fasciculata Heyne ex Roth. var. *glabrescens* C. B. Clarke in DC. Monogr. Phan. 3: 253, 1881.

Common, often in dense patches, but scarcely abundant species at Fitzgerald ghat, Chinaman's fall, Wilson point, Pratapsingh Park, Yenna lake, Lingmala and along Petit road in hard rocky grounds. Flowers blue turning bright purple at maturity. In Mahabaleshwar specimens there is gradual variation in this species from cottony-wooly to glabrous plants. Therefore we prefer to merge the variety *glabrescens* with the typical Variety.

FLOWERS: July-October.

3. **Cyanotis tuberosa** (Roxb.) Schult. f., Syst. 7: 1153, 1830; Dalz. & Gibs. 256; FBI 6: 386; Cooke, 2: 793 (3: 302-3); Santapau, 326.

Tradescantia tuberosa Roxb., Cor. Pl. 2: 5, t. 108, 1798; Graham, 223.

Common among grasses in rocky grounds, especially on way to Kate's point and Lingmala falls. Reddish purple flowers clustered in a head make this species very conspicuous along the forest fringes.

FLOWERS: September-October.

4. **Cyanotis wightii** C. B. Clarke, in DC. Monogr. 3: 250, 1881; FBI 6: 386; Birdwood 29; Cooke 2: 795 (3: 304); Puri & Mahajan. 135.

Cyanotis longifolia Wight, Icon. 6: 33, t. 2084, 1853 (non Benth. 1849).

This species is reported from Mahabaleshwar by T. Cooke.

Murdannia Royle

1. Inflorescence terminal, cymose paniculate 2
    2. Grass-like herbs; leaves needle-shaped ...... *M. nimmonii*
    2. Not grass-like herbs; leaves not needle-shaped 3
        3. Weak, prostrate or decumbent herbs 4
            4. Capsules 9 or less than 9 seeded ...... *M. nudiflorum*
            4. Capsule more than 9-seeded ...... *M. spiratum*
        3. Erect, robust herbs 5
            5. Roots tuberous ...... *M. simplex*
            5. Roots fibrous ...... *M. giganteum*
1. Inflorescence axillary, consisting of 1-3 flowers... 6
    6. Flowers ochre-yellow 7
        7. Filaments bearded ...... *M. versicolor*
        7. Filaments naked ...... *M. ochracea*
    6. Flowers blue 8
        8. Filaments bearded; seeds angular ...... *M. lanuginosa*
        8. Filaments naked; seeds cubical ...... *M. wightii*

1. **Murdannia gigantea** (Vahl) Bruckn. in Pfam. 15A: 173, 1930.

Commelina gigantea Vahl, Enum. 2: 177, 1806. *Aneilema giganteum* R. Br., Prodr. 271, 1880; FBI 6: 379; Cooke 2: 789 (3: 299); Puri & Mahajan, 135.

A. encifolium Wight, Icon. t. 2074, 1853.

This species is included here on authority of Cooke and Puri & Mahajan, who have reported it from Mahabaleshwar.

2. **Murdannia lanuginosum** (Wall. ex Clarke) Bruckn. in Pfam. 15A, 173, 1930.

Aneilema lanuginosum Wall. ex Clarke, in DC. Monog Phan. 3: 214, 1881; FBI 5: 380; Cooke, 2: 790 (3: 300); Puri & Mahajan, 135.

Rare erect herb near Lingmala, along roadsides with Ochre-yellow flowers.

FLOWERS: May-October.

3. **Murdannia nimmoniana** (Graham) Comb. Nov.

Commelina nimmoniana Graham, Cat. Bombay Pl. 224, 1839.

M. semeteres (Dalz.) Santapau, in Poona Agric. Coll. Mag. 41: 284, 1951 & Rec. Bot. Surv. Ind. 16(1): 325, 1953.

Aneilema semeteres Dalz. in Kew Journ. Bot. 3: 138, 1951; Dalz. & Gibs. 254.

A. paniculata Wall. ex Clarke, in DC. Monogr. Phan. 3: 815, 1881; FBI 6: 381; Cooke, 2: 790 (3: 300).

Dichaespermum juncoides Wight, Icon. t. 2078, 1853.

Common herb near Wilson point. Flowers blue. Leaves characteristically needle-shaped.

FLOWERS: July-September.

Note: The earliest name, *Commelina nimmoniana* Graham, is very often neglected by modern taxonomist as nomen sub-nudum, because it is not well described by Graham. But it is the only member of family Commelinaceae from its type locality with needle-shaped leaves which was well known to Cooke, and which was placed by him in the synonymy of *Aneilema paniculatum* Wall.

4. **Murdannia nudiflora** (Linn.) Bruckn., Kew Bull. 7: 189, 1952.

Commelina nudiflora Linn., Sp. Pl. 41, 1753 (pro parte), Graham, 223.

Aneilema nudiflorum (Linn.) Wall., List. 182, no. 5224, 1839 (non R. Br., 1810); Dalz & Gibs. 253; Cooke 2: 788 (3: 298).

M. malabarica (Linn.) Bruckn. in Pfam. ed. 2, 15A: 173, 1930; Santapau, in Journ. Bombay nat. Hist. Soc. 52; 658, 1955. *Tradescantia malabarica* Linn. Sp. Pl. ed. 2, 412, 1762.

Commelina communis Walter, Fl. Carol. 68, 1788; Dalz. & Gibs. 252; Cooke, 651, 1885.

Common herb among grasses.

FLOWERS: September-October.

5. **Murdannia ochracea** (Dalz.) Bruckn., in Engl. & Prantl. Pfam. 15A: 173, 1930.

Aneilema ochraceum Dalz., in Kew Journ. Bot. 3: 135, 1851.

Dichaespermum repens Wight, Icon. 6: 31, t. 2078, f. 3, 1853 (non Hask., 1881).

This species is known from a single collection from Mahabaleshwar (BSI—No. 67575).

6. **Murdannia simplex** (Vahl) Brenan, Kew Bull. 1952: 186, 1952; Gandhi, Fl. Hassan 649, 1976.

Commelina simplex Vahl, Enum. 2: 177, 1806.

Aneilema sinicum Ker-Gawler, Bot. Reg. t. 659, 1822; FBI 6: 379; Birdwood 29; Cooke, 2: 789 (3: 299); Puri & Mahajan, 134.

A. secundum Wight, Icon. t. 2075, 1853.

Very common and abundant, very often gregarious herb in moist grounds along roadsides, in open grass-lands and along edges of forests. Tallest species in the genus, easily distinguishable due to its tuberous roots and blue flowers. Collected from Lingmala, Kate's point, Lodwick point & Bhilar estate.

FLOWERS: August-September.

7. **Murdannia spiratum** (Linn.) Bruckn., in Engl. & Prantl., Pfam., ed. 2, 15A: 173, 1930; Santapau, 324.

Commelina spirata Linn. Mant. 1: 176, 1767. *Aneilema spiratum* R. Br., Prodr. 271, 1810 (in adnot); FBI 6: 377; Birdwood, 29; Cooke 2: 787 (3: 296-7); Puri & Mahajan, 134.

A. canaliculatum Dalz. in Kew Journ. Bot. 3: 137, 1851; Dalz. & Gibs. 254.

A. nanum Kunth. Enum. 4: 65, 1843; Wight, Icon. t. 2977, 1853.

Occasional among grasses in hard rocky grounds.

FLOWERS: July-November.

8. **Murdannia wightii** Rao et Kamathy, in Bull. Bot. Surv. India, 3: 168, 1961.

M. pauciflorum (Wight) Bruckn., in Engl. & Prantl., Pfam. 15A: 173, 1930. *Aneilema pauciflorum* Wight, Icon. t. 2077, 1853 (non Dalzell, 1851); FBI 6: 378; Birdwood, 29; Cooke, 2: 788 (3: 297); Puri & Mahajan, 134.

This species also known from a single collection from Mahabaleshwar by T. Cooke.

FLOWERS: October.

9. **Murdannia versicolor** (Dalz.) Bruckn., in Pfam., ed. 2, 15A: 173, 1930; Santapau, 324.

Aneilema versicolor Dalz. in Kew Journ. Bot. 3: 136, 1851; Dalz. & Gibs. 253; FBI 6: 378; Cooke 2: 788 (3: 298).

Occasional among grasses in moist and sloping grounds. Common at Babington point, Dhobi's falls, Lingmala, Lodwick point and in Pratapsingh Park.

FLOWERS: September-November.

ARECACEAE

1. Basal leaflets not spinous .... *Caryota*
1. Basal leaflets spinous .... *Phoenix*

Caryota Linn.

1. **Caryota urens** Linn. Sp. Pl. 1189, 1753; Graham, 226; Dalz. & Gibs. 278; FBI 6: 422; Birdwood, 29; Cooke 2: 805 (3: 315-6); Puri & Mahajan, 135.

Rare palm along forest margins.

FLOWERS: Throughout the year.

LOCAL NAMES: Bherli mad, Fish-tail palm.

Phoenix Linn.

1. **Phoenix sylvestris** (Linn.) Roxb., Fl. Ind. 3: 787, 1832; Graham, 224; Dalz. & Gibs. 278; Cooke 2: 801 (3: 311).

Elate sylvestris Linn. Sp. Pl. 1189, 1753 (pro parte).

Rare palm at Mahabaleshwar.

FLOWERS: January-February.

LOCAL NAME: Shindi, Wild date palm.

ARACEAE

1. Plants not climbers 2
    2. Aquatic or marsh plants, without tubers .... *Cryptocorine*
    2. Terrestrial tuberous herbs 3
        3. Flowers bisexual (spadix homogenous); venation striate .... *Zantedeschia*
        3. Flowers unisexual; venation reticulate 4
            4. Leaves simple 5
                5. Plants bearing leafless bulbiferous shoots .... *Remusatia*
                5. Plants without leafless bulbiferous shoots 6
                    6. Spadix with a barren terminal appendix 7
                        7. Ovules many, parietal .... *Colocasia*
                        7. Ovules few, basal .... *Alocasia*
                    6. Spadix without barren terminal appendix 8
                        8. Leaves not variegated .... *Ariopsis*
                        8. Leaves variegated .... *Caladium*
            4. Leaves compound 9
                9. Male flowers stipitate; flowers diocious .... *Arisaema*
                9. Male flowers sessile or so; flowers always monoecious .... *Amorphophallus*
1. Climbers 10
    10. Leaves pinnately cut or perforated .... *Monstera*
    10. Leaves entire 11
        11. Leaves with reticulate venation .... *Epipremnum*
        11. Leaves with parallel venation .... *Rhaphidophora*

Amorphophallus Blume ex Decaisne (nom. cons.)

1. **Amorphophallus commutatus** (Schott.) Engler, in DC. Monogr. 2: 319, 1879; FBI 6: 515; Lisboa. Journ. Bombay nat. Hist. Soc. 10: 527, 1896; Cooke, 2: 826 (3: 337); Santapau, 291.

Conocephalus commutatus Schott.. in Bonaplan. 7: 28, 1859.

Thomsonia nepalense sensu Birdwood l.c. 29, (non Wall. Pl. As. Rar. 1: 83, t. 99, 1839).

A. sylvaticus Dalz. & Gibs. Bombay Fl. 256, 1861 (non Kunth., 1841).

Pythonium wallichianum Kirtikar, in Journ. Bombay nat. Hist. Soc. 7: 312, 1893 (non Schott., 1832).

Synantherias sylvatica Schott., Gen. Aroid. t. 28, 1858; Birdwood 29; FBI 6: 518.

Dracontium polyphyllum Graham. Cat. Bombay Pl. 229, 1839 (non Dennst., 1819).

Common along Fitzgerald ghat, in partially shaded places. Vegetative shoots appear after flowering spadix in monsoon. Spathe is purple coloured with white blotches.

FLOWERS: May-June.

LOCAL NAMES: Sheula, Sheuli.

Alocasia (Schott.) G. Don (nom. cons.)

1. **Alocasia indica** (Roxb.) Schott. in Oestr. Bot. Wochenol 410, 1854; FBI 6: 525; Cooke, 2: 830 (3: 341).

Cultivated for its stems and root-stocks which are used as vegetables.

Ariopsis Nimmo

1. **Ariopsis peltata** Nimmo ex Graham, Cat. Bombay Pl. 252, 1839; Dalz. & Gibs. 259; FBI 6: 519; Cooke 2: 827 (3: 338); Santapau, 288, 1963.

Remusatia vivipara Wight, Icon. t. 900, 1844 (non Schott, 1832).

Rare species in shady places in rocky grounds. Very often found in crevices of rocks and among stones in broken old walls.

FLOWERS: June-August.

Arisaema Martius

1. Leaves 2-3 together 2
   2. Leaf-segments pedatisect ...... *A. tortuosum*
   2. Leaf-segments radiatisect ...... *A. neglectum*
1. Leaves solitary 3
   3. Leaflets petiolate .... *A. caudatum*
   3. Leaflets sessile 4
      4. Leaves appearing after the flowers; spathe 9-12 cm long .... *A. murrayi*
      4. Leaves and spathes appearing simultaniously; spathe 6-18 cm. long .... *A. leschenaultii*

1. **Arisaema caudatum** Engler, in DC. Monogr. Phan. 2: 559, 1879; FBI 6: 508; Rolla Rao & Ahuja, Bull. Bot. Surv. India 11: 450, 1969.

A. longecaudatum Blatter, in Asiat. Soc. Bengal 26: 362, 1930 & J. Bombay nat. Hist. Soc. 35: 20, 1931; Chatterjee, in Bull. Bot. Soc. Bengal 8: 128, 1954; Santapau, 401, 1962 & 288, 1963.

Very common and abundant herb all over Mahabaleshwar in monsoon.

FLOWERS: June-September.

2. **Arisaema leschenaultii** Blume, Rumphia 1: 93, 1835; FBI 6: 504; Lisboa, 223; Cooke, 2: 821 (3: 332); Blatter & McCann, J. Bombay nat. Hist. Soc. 35: 19, 1931.

Arum crubescens Dalz. & Gibs. Bombay Fl. 258, 1861 (non Schott., 1830).

Rare, in shady places among the undergrowth in the forest areas.

FLOWERS: June-September.

3. **Arisaema murrayi** (Graham) Hook. f., in Bot. Mag. t. 4388, 1848; FBI 6: 507; Dalz. & Gibs. 258; Nairne, 362; Cooke 651 & 2: 281 (3: 332); Birdwood 28; Lee 466; Blatter & McCann, l.c. 18; Puri & Mahajan, 135.

Arum murrayi Graham, Cat. Bombay Pl. 229, 1839.

Fairly common perennial herb all over, usually occurring in groups of 5-7 plants together, during monsoon.

FLOWERS: June-July.

LOCAL NAME: Sapacha kanda.

4. **Arisaema neglectum** Schott., in Bonapald. 7: 26, 1859; FBI 6: 504; Blatter & McCann, l.c. 21.

A. tortuosum (Wall.) Schott. var. *neglectum* (Schott.) Fisher, in Gamble, Fl. Madras Pres. 1585, 1931.

A rare herb among grasses with radiatisect leaflets.

FLOWERS: June.

5. **Arisaema tortuosum** (Wall.) Schott., in Schott. & Endl. Melet. Bot. 17, 1832; FBI 6: 502; Cooke, 2: 820 (3: 331-2).

Arum tortuosum Wall., Pl. Asiat. Rare. 2: 10, t. 111, 1830.

Arisaema curvatum Dalz. & Gibs., Bombay Fl. 258, 1861 (non Kunth., 1841); Hooker, Bot. Mag. t. 5931, 1871.

Common species in partially shady places.

FLOWERS: June.

Caladium Vent.

1. **Caladium bicolor** Vent., Jard. Cels. t. 30, 1800; Baily, Man. cult. Pl. 188, 1949.

Quite commonly cultivated in gardens as an ornamental plant.

FLOWERS: July.

Colocasia Schott.

1. **Colocasia esculenta** (Linn.) Schott., in Schott. & Endl. Melet. 1: 18, 1832; Bailey, Man. Cult. Pl. 189, 1949.

Arum esculentum Linn. Sp. Pl. 965, 1753.

Colocasia antiquorum Schott., in Schott. & Endl., Melet 1: 18, 1832; FBI 6: 523; Cooke 2: 829 (3: 340-41); Blatter & McCann, in Journ. Bombay nat. Hist. Soc. 35: 29, 1931; Santapau, 293.

Rare species in cultivation. Leaves are used as vegetable.

LOCAL NAME: Alu.

Cryptocorine Fisher

1. Tube of the spathe much longer than the limb .... *C. retrospiralis*
1. Tube of the spathe much shorter than the limb .... *C. spiralis*

1. **Cryptocorine retrospiralis** (Roxb.) Fisher ex Wydler, in Linnaea 5: 428, 1830; FBI 6: 493; Wight, Icon. t. 772, 1844; Cooke 2: 818 (3: 329).

C. roxburghii Dalz. & Gibs., Bombay Fl. 259, 1861 (non Schott., 1832); Cooke, 651, 1885; Birdwood 29.

Arum spirale Graham, Cat. Bombay Pl. 228, 1839 (non Retz. 1779).

Ambrosinia retrospiralis Roxb., Fl. Ind. 3: 492, 1832.

Common on margins of pools, lake and beds of streams as well as in rice-fields, near Lingmala. Plants are usually found partially submerged under water.

FLOWERS: November-February.

2. **Cryptocorine spiralis** (Retz.) Fisher ex Wydler, Linnaea 5: 428, 1830; FBI 6: 494; Wight, Icon. t. 773, 1844; Cooke, 2: 818 (3: 329).

Arum spirale Retz. Obs. Bot. 1: 30, 1779.

C. hugellii Schott., Gen. Aroid, 8, t. 12, 1853; FBI 6: 494, 1893.

C. tortuosa Blatter, & McCann, J. Bombay nat. Hist. Soc. 35: 16. t. 1, 1931; Santapau, 398, 1962 & 288, 1963.

This species is found abundantly along the margins of Yenna lake and near Lingmala.

FLOWERS: August-December.

Epipremnum Schott.

1. **Epipremnum aureum** (Linden ex Andre) Bunting in Ann. Missouri Bot. Gard. 1: 78, 1964.

Pothos aurea Linden ex Andre, in Illustr. Hortic. 27: 69, t. 381, 1880; Cooke, 2: 818 (3: 340).

Commonly cultivated in gardens as well as indoor ornamental plant.

LOCAL NAME: Money plant.

Monstera Adanson (nom. cons.)

1. **Monstera deliciosa** Liebm. Videnk. Meddel. Dansk. Naturalist. Foren. Kjobenhaur 1 & 2: 19, 1849; Bailey, Man. Cult. Pl. 183, 1949.

Rarely cultivated in gardens as an ornamental plant.

Remusatia Schott.

1. **Remusatia vivipara** (Roxb.) Schott., Melet. 1: 18, 1832; FBI 6: 521; Cooke 649, 1885 & 2: 828 (3: 339); Blatter & McCann, J. Bombay nat. Hist. Soc. 35: 30 1931; Santapau, 400, 1962 & 288, 1963.

Arum viviparum Roxb., Fl. Ind. 3: 496, 1832; Graham, 228; Wight, Icon. t. 798, 1844; Birdwood, 29.

Caladium viviparum Lodd., Bot. Cat. t. 281, 1820.

Colocasia vivipara Thwaites, Enum. 336, 1784.

Common epiphytic or lithophytic herb all over. Usually the plants are found associated with leafless reddish-brown shoots covered with bulbils, which resemble tiny flowers, We have not come across flowering specimen in the area under study.

Rhaphidophora Hasskarl

1. **Rhaphidophora pertusa** (Roxb.) Schott., Bonaplandia 5: 45, 1857; FBI 6: 546; Cooke 2: 831 (3: 342).

Pothos pertusa Roxb., Fl. Ind. 1: 455, 1820; Graham, 230.

Scindapsus pertusus Schott. in Schott. & Endl. Melet. 1: 21, 1832; Wight, Icon. t. 781, 1844.

Rarely cultivated in gardens as an ornamental climber.

Zantedeschia Sprengel (nom. cons.)

1. **Zantedeschia aethiopica** (Linn.) Sprengel, in Linn. Syst. Veget. ed. 16, 3: 735, 1826; Bailey, Manual Cult. Pl. 181, 1949.

Calla aethiopica Linn. Sp. Pl. 968, 1753.

This tropical African introduced species has been collected by Rev. Fr. H. Santapau, from

Lingmala, which is probably an escape from cultivation.

FLOWERS: September.

LEMNACEAE

1. Fronds flat, with one or more roots, bearing the flowers in marginal clefts; anthers 2-celled; filaments slender .... *Lemna*
1. Fronds minute, like grains of sand, root-less, proliferous, bearing the flowers on the upper surface; anthers sessile, one-celled ...... *Wolffia*

Lemna Linn.

1. Roots solitary .... *L. trisulca*
1. Roots many .... *L. polyrhiza*

1. **Lemna trisulca** Linn. Sp. Pl. 970, 1753; Dalz. & Gibs. 281; FBI 6: 557; Birdwood, 29; Cooke 2: 831 (3: 343).

Common floating herb in stagnant waters in ponds and in ricefields.

FLOWERS: September.

LOCAL NAME: Duck weed.

2. **Lemna polyrhiza** Linn. Sp. Pl. 970, 1753; FBI 6: 557; Birdwood 29; Cooke, 2: 832 (3: 433).

Rare weed in ponds and in rice-fields, in stagnant waters.

FLOWERS: September.

Wolffia Horkel

1. **Wolffia arrhiza** (Linn.) Horkel, ex Wimm., Fl. Schles, ed. 3, 140, 1857; Birdwood 29.

Lemna arrhiza Linn., Mantissa 2: 294, 1771; Syme, Eng. Bot. ed. 3, 9: 24, t. 1398, 1869.

L. globosa Roxb. Fl. Ind. 3: 565, 1832; Graham, 252; Dalz. & Gibs. 281.

Wolffia globosa (Roxb.) Horteg & Vander Plas Blumea 18: 367, 1970.

W. michellii Schleid. Beitr. Bot. 233, 1844; Cooke 2: 832 (3: 344).

Tiny weed in stagnant waters, covering water surface like green scum.

FLOWERS: September.

ERIOCAULACEAE

Eriocaulon Linn.

1. Anthers white or yellow 2
2. Plants of marshy places; heads 1 cm across .... *E. horsely-kondae*
2. Plants of pools and wet grounds; heads 0.5 cm or less across .... *E. mitophyllum*
1. Anthers black 3
3. Sepals of the female flowers deeply boat-shaped; keel thickened or expanded into a wing or crest 4
4. Head under 1 mm. in diameter 5
5. Female sepals equal, equally crested .... *E. margarettae*
5. Female sepals unequal, one not crested .... *E. eleanorae*
4. Heads 5 mm or more in diameter .... *E. stellulatum*
3. Sepals of the female flowers not boat-shaped; keel not thickened 6
6. Male flowers with one enlarged petal projecting beyond floral bracts 7
7. Leaves 2-5 cm long, lanceolate; scapes15-25 cm long .... *E. odoratum*
7. Leaves 4.5-6 cm long, linear; scapes 30-45 cm long .... *E. cristatum*
6. Male flowers not with enlarged petal 8
8. Stems disciform, 0; floral bracts black 9
9. Receptacle villous 10
10. Inflorescence bracts obtuse; horizontal 11
11. Female petals linear .... *E. thwaitesii*
11. Female petals absent .... *E. nigricans*
10. Involucral bracts reflexed, shorter than heads .... *E. sedgwickii*
9. Receptacle glabrous 12
12. Heads 4-6 mm across; female petals glabrous .... *E. duthiei*
12. Heads 7-10 mm across; female petals hairy in upper part .... *E. bolei* sp. nov.
8. Stems elongated, slender .... *E. setaceum*

1. **Eriocaulon cristatum** Mart. in Wall. Pl. As. Rar. 3: 28, 1832; FBI 6: 574; Fyson, Ind. Sp. Erioc. 48, t. 31.

E. miserum Koern. in Linnaea 27: 607, 1856.

Rare species at Mahabaleshwar. It has been collected from Bhilar estate.

FLOWERS: November.

2. **Eriocaulon duthiei** Hook. f. in Fl. Brit. India 6: 578, 1983; Fyson, Ind. Sp. Erioc. 27, t. 7.

Rare species on sides of stream near Bhilar. Herbarium specimen was identified by H. N. Moldenke as *E. odoratum* Dalz. but our specimen differ from *E. odoratum* Dalz. in having boat-shaped sepals in female flowers and having smaller heads.

FLOWERS: November.

3. **Eriocaulon eleanorae** Fyson, in Journ. Indian Bot. 2: 316, 1921 & Ind. Sp. Eriocaulon 52, t. 35; Santapau 294.

Quite common and gregarious in rocky grounds near Lingmala, Kate's point and Yenna Lake.

FLOWERS: September-October.

4. **Eriocaulon margarettae** Fyson, in Journ. Indian Bot. 2: 316, 1921 & Ind. Sp. Eriocaulon 52, 1923.

E. humile Moldenke, Phytologia 3: 162, 1949; Santapau, 294-5.

Rare species at Mahabaleshwar and at Bhilar among the grasses. Some specimens of this in Blatter Herbarium (BLAT) have been misidentified as *E. quinqueloculare* Linn., but Mahabaleshwar specimens lack in red coloured leaves and belong to this species.

FLOWERS: October-November.

5. **Eriocaulon mitophyllum** Hook. f., in Flora Brit. India 6: 575, 1893.

E. miserum Koern. var. *mitophyllum* (Hook. f.) Fyson, Ind. Spec. Eriocaulon 59, t. 48, 1923.

Common and abundant species on rocky grounds very often partially submerged in puddles. Very common at Wilson point, Petit road and near Pratapsingh park.

FLOWERS: July-September.

6. **Eriocaulon nigricans** R. Br. Prodr. 254, 1810.

Eriocaulon achiton Koern. in Linnaea 27: 630, 1854. FBI 6: 584; Fyson, Ind. Sp. Eriocaulon 29-30, f. p. 30, 1923.

This species is known from Mahabaleshwar from a single Collection (S. C. Tavakari — s.n. B), from Chinaman's falls.

FLOWERS: October.

7. **Eriocaulon odoratum** Dalz. in Kew Journ. Bot. 3: 280, 1851; Dalz. & Gibs. 280; FBI 6: 574; Cooke, 2: 844 (3: 355-6); Fyson, Ind. Sp. Erioc. 44, t. 28.

Common and abundant and one of the dominent species in rocky grounds near Wilson point, Pratapsingh park and Bhilar Estate, among grasses.

FLOWERS: September-November.

8. **Eriocaulon horsley-kondae** Fyson, in Journ. Ind. Bot. 3: 13, 1922 & Ind. Spec. Eriocaulon, 58, t. 43, 1923.

Common herb on moist rocky grounds along with *E. odoratum* Dalz. on Wilson point.

FLOWERS: September-October.

9. **Eriocaulon setaceum** Linn. Sp. Pl. 87, 1753; Cooke 2: 842 (3: 354); Fyson, Ind. Sp. Erioc. 20, t. 1.

E. capillus-naiadis Hook. f., Fl. Brit. India. 6: 572, 1893.

Rare species found on margins of Yenna lake with black flowering heads.

FLOWERS: November.

10. **Eriocaulon stellulatum** Koern. in Linnaea 27: 620, 1856; FBI 6: 579; Cooke, 2: 846 (3: 358); Fyson, Ind. Sp. Erioc. 53, f. 55.

Very common and abundant herb among grasses at Bhilar estate, Madhukosh, Lodwick point, Chinaman's falls, Lingmala, Dhobi's falls and near Yenna lake.

FLOWERS: October-December.

11. **Eriocaulon sedgwickii** Fyson, Journ. Ind. Bot. 2: 260, 1921 & Ind. Sp. Eriocaulon, 36, t. 16, 1923.

Rare species at Mahabaleshwar. There are no other collection of this species at Blatter herbarium, other than type specimen collected by L. J. Sedwick.

FLOWERS: November.

12. **Eriocaulon thwaitesii** Koern., in Linnaea 27: 627, 1854; Fyson, Ind. Sp. Erioc. 29 & 68. 1923.

This species has been reported from Lingmala, Mahabaleshwar by Fyson, (Sedgwick—4646).

13. **Eriocaulon bolei** sp. nov. Similis *Eriocaulon sedgwickii* Fyson sed differt laevibus capitibus. Similis *E. duthiei* Hook. f. sed differt prolatis capitibus.

Holotypus — P. V. Bole 2230 (BLAT) lectus Lingmala, Mahabaleshwar die 6.11.1955.

Herbs 4-8″ tall, with sheaths 1.5-2″ long. Scapes glabrous. Leaves small, lanceolate. Heads ± 1 cm across, white. Bracts covering the floral parts completely. Male flowers 1-3 in a single bract. Sepals 2, lanceolate or spathulate. Petals united into a tube. Stamens 4-6. Anthers black; basifixed. Female flowers 1-2 in each bract, sepals 2, boat-shaped, hairy on the back. Petals linear, with faint black spots, with long white hairs. Ovary trilocular, style with trifid stigma. Nut brown-red.

Gregarious herb on side of a stream in running water near Lingmala.

FLOWERS: November.

There is one specimen of this species in Blatter Herbarium, collected by the Senior author on way to Lingmala via Panchgani Road.

Exsiccata: P. V. Bole — 2230 (6-11-1955).

It comes near to *E. sedgwickii* Fyson, and *E. duthiei* Hook. f. It differs from the former in having glabrous heads whereas it differs from the latter due to its longer heads.

CYPERACEAE

1. Nut enclosed in an utricle .... *Carex*
1. Nut not enclosed in an utricle 2
    2. Glume distichous in entire inflorescence 3
        3. Rhachilla of spikelets disarticulating above two lowest glumes .... *Mariscus*
        3. Rhachilla of spikelets persistant .... *Cyperus*
    2. Glumes spirally imbricately arranged 4
        4. Style base persistant, swollen, when caducous not leaving a tumour on the nut.... .... *Fimbristylis*
        4. Style base deciduous, leaving a tumour on the nut .... *Bulbostylis*

Bulbostylis Kunth.

1. **Bulbostylis densa** (Wall.) Hand.-Mazz. in Karsten & Schenk, Vegetation 20, 7: 16, 1930; Santapau, 303.

Scirpus densus Wall. ex Roxb. Fl. Ind. 1: 231. 1820.

B. trifida Kunth., Enum. 2: 213, 1837.

B. capillaris Nees var. *trifida* (Kunth.) C. B. Clarke, in Flora Brit. Ind. 6: 652, 1894; Blatter & McCann, Journ. Bombay nat. Hist. Soc. 37(4): 765-1935.

Common herb among grasses at Shindola summit.

FLOWERS: November.

Carex Linn.

1. Spikes long-cylindric; peduncles 1-2 in each sheath .... *C. baccans*
1. Spike short, numerous, without sheaths 2
    2. Each spikelet with 3-4 nuts ...... *C. cruciata*
    2. Each spikelets with 6-10 nuts 3
        3. Nut ovate-elliptic, not stipitate .... *C. glaucina*
        3. Nut ovate, short stipitate .... *C. lindleyana* var. *major*

1. **Carex baccans** Nees, in Wight Contr. 122, 1834; FBI 6: 722; Blatter & McCann, 765.

Rare, robust species in wet places.

FLOWERS: November.

2. **Carex cruciata** Wahlenb. in Vet. Akad. Handl. Stockholm 24: 149, 1803; FBI 6: 715; Blatter & McCann, J. Bombay nat. Hist. Soc. 38(1): 7, 1935.

C. condensata Nees, in Wight Contr. 123, 1834; FBI 6: 716; Cooke 2: 905 (3: 420); Puri & Mahajan, 134.

C. indica Nees, in Wight, Contri. 123, 1834 (non Linn. 1753); Graham 233; Dalz. & Gibs. 288; Cooke 651, 1885; Birdwood 29.

Common along road-sides and along forest fringes near Chinaman's fall and Lodwick point. Tolerates shade to a great extent.

FLOWERS: October-December.

LOCAL NAME: Lavicha Gavat.

3. **Carex glaucina** Boeckler, in Linnea 40: 353, 1876.

C. filicina Nees var. *glaucina* (Boeck.) Kukenthal, Pflanzenr. 38: 274; 1909; Santapau, 303.

In wet places near Chinaman's falls, Petit road, Lingmala, Babington point, Madhukosh and Lodwick point.

FLOWERS: October-December.

4. **Carex lindeyana** Nees var. **major** Fisher, in Gamble, Fl. Pres. Madras 3: 1169, 1928.

C. mercarensis Hochst. var. *major* Steud. Syn. Pl. Cyper. 194, 1855; FBI 6: 719; Cooke, 2: 906 (3: 421); Puri & Mahajan, 135.

C. mercarensis Woodrow, Journ. Bombay. Nat. Hist. Soc. 13: 433, 1901.

Occasional in shady places in forest areas.

Rare along Petit Road and near Yenna lake.

FLOWERS: October-March.

Cyperus Linn

1. Stigmas 2 2
2. Rhachilla deciduous as a whole .... *C. brevifolius*
2. Rhachilla persistent 3
3. Superfiicial cells of the nut nearly square .... *C. globosus*
3. Superficial cells of the nut longitudinally oblong or elliptic 4
4. Spikelets lanceolate, 20-60 flowered; nut obovoid, black .... *C. latespicatus*
4. Spikelets linear-oblong with exactly parallel sides; ± 20 flowered; nut globosely ovoid, brown .... *C. malabaricus*
1. Stigmas 3 5
5. Rhachilla of the spikelets not winged .... *C. nutans*
5. Rhachilla of the spikelets 2-winged 6
6. Leaves short, rarely half as long as the stem or absent 7
7. Rhizome short, stoloniferous .... *C. macer*
7. Rhizome elongated, not stoloniferous 8
8. Bracts linear-enciform, shorter than the inflorescence, to 5 cm long, 3 cm wide; wing of rhachilla narrow, pale in colour .... *C. corymbosus*
8. Bracts longer than the inflorescence, upto 60 cm long and 7 mm wide; wing of the rhachilla broad, red in fruiting specimens .... *C. pangorei*
6. Leaves long, often longer than the stem .... *C. rotundus*

1. **Cyperus brevifolius** (Rottb.) Hassk. Cat. Hort. Bogor. 24, 1844.

Kyllingia brevifolia Rottb., Desr. et Ic. 13, t. 4. f. 3, 1773; Blatter & McCann 25.

Rare species at Mahabaleshwar, found in wet places along water courses.

FLOWERS: October.

2. **Cyperus corymbosus** Rottb., Desr. & Icon. 42, t. 7, f. 4, 1773; FBI 6: 612; Cooke, 2: 870 (3: 383); Blatter & McCann 270.

In gregarious patches near banks and along water-courses. Always associated with araceous plants (*Cryptocorine* spp.).

FLOWERS: August-November.

3. **Cyperus digitatus** Roxb., Fl. Ind. 1: 205, 1832; FBI 6: 599; Cooke, 2: 862 (3: 387); Blatter & McCann 259.

Rare herb along water-courses.

FLOWERS: November.

4. **Cyperus globosus** Allioni, Fl. Pedem. 49, 1789; Cooke 2: 857 (3: 370); Puri & Mahajan, 135.

Pycreus globosus Reich., Fl. Germ. Exc. 140, 1830; Blatter & McCann 29.

P. capillaris Nees, in Linnaea 9: 283, 1834; FBI 6: 591; Birdwood 29.

P. flavidus Retz., Obs. 5: 13, 1789 (nec Clarke 1893).

Common in moist places.

FLOWERS: October.

5. **Cyperus latespicatus** Boeck., in Flora 42: 441, 1859; Cooke 2: 855 (3: 368); Puri & Mahajan 135.

Common among the grasses and in rocky hard grounds at Shindola summit, Lodwick point and Wilson point.

FLOWERS: November.

6. **Cyperus macer** C. B. Clarke, in Journ. Linn. Soc. London, 21: 160, 1884.

Rare along sides of streams on hill slopes, near Lingmala.

FLOWERS: November.

7. **Cyperus malabaricus** (Clarke) Cooke, Fl. Pres. Bombay 2: 856, 1908.

Pycreus malabaricus Clarke, in Journ. Linn. Soc. London 34: 12, 1898; Blatter & McCann 28, t. 3.

Common herb in moist places and on sides of rice fields.

FLOWERS: October-November.

8. **Cyperus nutans** Vahl, Enum. 2: 363, 1806; Cooke, 2: 868 (3: 381); Santapau, 300.

C. distans Graham, Cat. Bombay Pl. 232, 1839 (non Linn., 1753); Dalz. & Gibs. 283.

Rare sedge near Babington point.

FLOWERS: October-November.

9. **Cyperus pangorei** Rottb. Desr. & Icon. 31, t. 7, f. 3. 1773 (non Retz., 1789); neck C. B. Clarke, 1893).

C. corymbosus Kunth., Boeck. et Alior. (non Rottb., 1773).

C. tagetum Roxb., Fl. Ind. 1: 208, 1832; FBI 6: 613.

Common sedge in running water of Yenna stream, in rivulets near Chinaman's fall and near Dhobi's fall.

FLOWERS: August-October.

Mariscus Gaertn.

1. Spikelets in compact single head .... *M. blatteri*
1. Spikelets in umbellate inflorescence 2
  2. Spikelets distant along the rhachis .... *M. konkanensis*
  2. Spikelets closely packed along the rhachis .... *M. cyperinus*

1. **Mariscus blatteri** McCann, in Journ. Bombay nat. Hist. Soc. 37(3): 532-3, 1934.

Rare species with compact single head. Head 1.5-2 cm across.

FLOWERS: October.

2. **Mariscus cyperinus** (Retz.) Vahl, Enum. 2: 377, 1806.

Kyllinga cyperina Retz. Obs. Bot. 6: 21, 1791.

Scirpus cyperoides Linn. Mant. 2: 181, 1771. (non *M. cyperiodes* (Roxb.) A. Distr. 1833).

Cyperus cyperoides (Linn.) O. Kuntze, Rev. Gen. 2: 333, 1898.

Common herb along road-sides in Fitzgerald ghat.

FLOWERS: August-October.

3. **Mariscus konkanensis** (Cooke) Sedgwick, in Journ. Bombay nat. Hist. Soc. 25: 698, 1918; Blatter & McCann, 535.

Cyperus konkanensis Cooke, Fl. Pres. Bombay 2: 874, 1908.

M. sieberianus Nees var. *subcomposita* Clarke, in Fl. Brit. Ind. 6: 522, 1893.

C. cyperoides (Linn.) O. Kuntze var. *subcomposita* (Clarke) Kukenth., in Pfrech. 101: 516, 1936.

Rare herb on sides of streams among grasses on Southern side of the Plateau.

FLOWERS: November.

(to be continued)

THE BIRDS OF THE KEDARNATH SANCTUARY, CHAMOLI DISTRICT, UTTAR PRADESH: STATUS AND DISTRIBUTION[1]

MICHAEL J. B. GREEN[2]

(*With a plate and a text-figure*)

Ornithological data obtained during three years spent in the Kedarnath Sanctuary of the Garhwal Himalaya, North India are presented. A total of 146 species were identified, including *Muscicapa westermanni, Seicercus poliogenys* and *Certhia nipalensis* which have not previously been recorded west of Nepal. Species accounts include details of altitudinal distribution, status, habitat and behaviour.

INTRODUCTION

Information about the birds of the Kedarnath Sanctuary in the Garhwal Himalaya of Chamoli District has not previously been documented. Furthermore, published observations concerning the avifauna of the Garhwal Himalaya are limited. Osmaston (1921) noted 96 species during his ten years' residence in the region, Lavkumar (1956) recorded 133 species during a two month visit in early summer and Devillers (1976) observed 93 species in the course of a three week expedition in spring.

The purpose of this paper is to list 146 species recorded in the Kedarnath Sanctuary during a three year study of the Himalayan musk deer *Moschus chrysogaster*, from February 1979 to December 1981 (see Green 1985). Of this total, 40 species are not mentioned in the lists of either Osmaston, Lavkumar or Devillers. Several species have not previously been recorded west of Nepal according to Ali and Ripley (1968-74), Fleming *et al.* (1976) and Inskipp and Inskipp (1985). These are the Little Pied Flycatcher *Muscicapa westermanni,* Grey-cheeked Warbler *Seicercus poliogenys* and Nepal Tree Creeper *Certhia nipalensis.* In addition, the upper altitudinal limit of 14 species is higher than that given by these authorities.

Identifications are based on field observations. Specimens were not collected except in the case of several species of game bird, which were inadvertently caught in box traps set for musk deer. Weights and measurements of these specimens are appended. Observations were not standardised and most were made at the southern edge of the sanctuary, within a triangular area lying between Chopta Chatti, Tungnath and Mandal and referred to as the main study area (Fig. 1). Other observations were made during visits to Bisuri Tal, Kedarnath, Madhyamaheshwar and Rudranath (Fig. 1).

KEDARNATH SANCTUARY

The sanctuary was created in 1972 and takes its name from the famous Hindu shrine at Kedarnath. It is situated about 300 km northeast of Delhi and, covering an area of 975 km^2, is the largest protected area in the Himalaya

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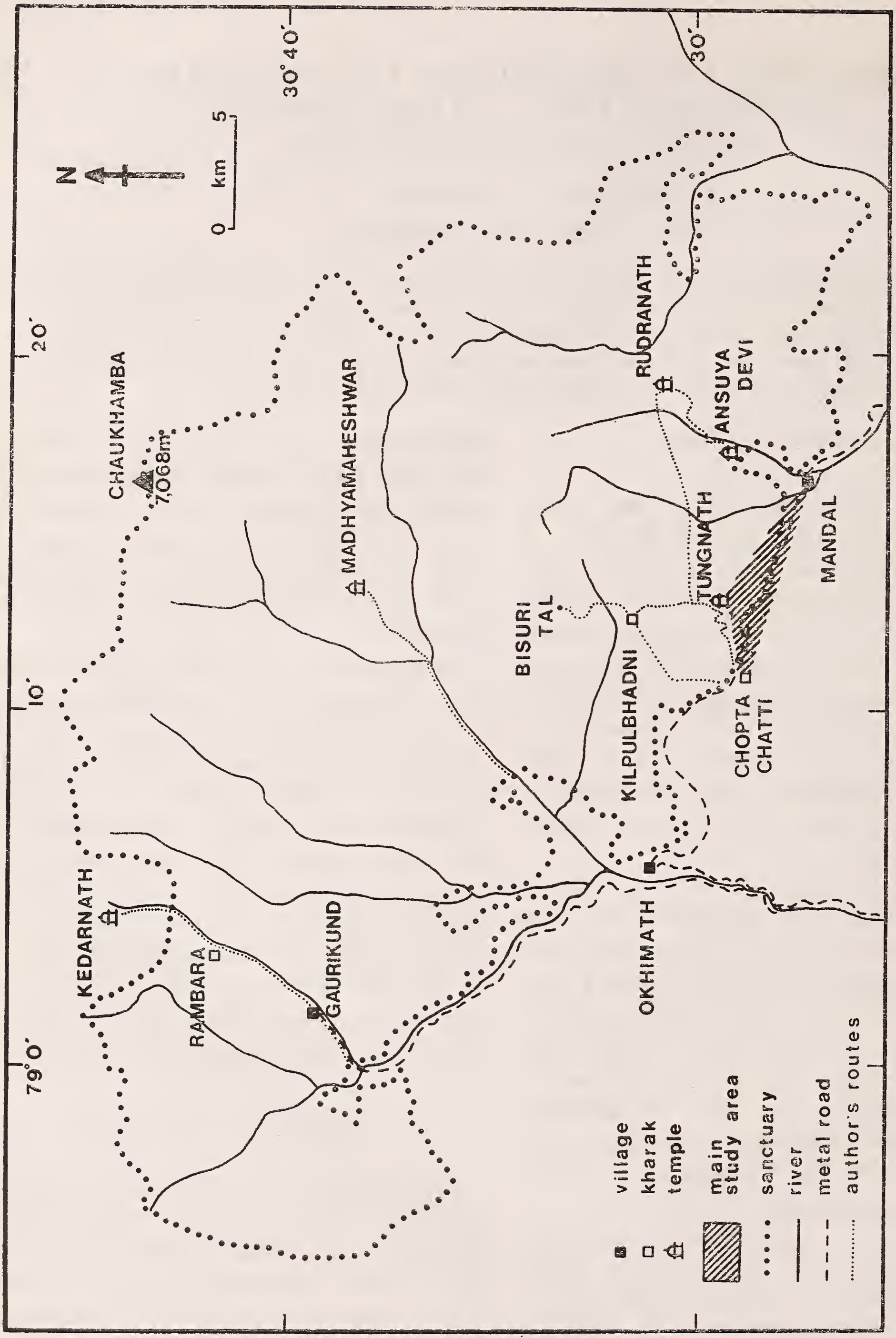
N
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30°40′
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KEDARNATH
RAMBARA
GAURIKUND
CHAUKHAMBA
7,068m
MADHYAMAHESHWAR
OKHIMATH
KILPULBHADNI
BISURI TAL
CHOPTA CHATTI
TUNGNATH
RUDRANATH
ANSUYA DEVI
MANDAL
■ village
□ kharak
temple
▨ main study area
• • • • sanctuary
—— river
- - - - metal road
········ author's routes

Fig. 1. A map of the Kedarnath Sanctuary showing the main study area and routes taken to other parts of the sanctuary.

of India. The entire sanctuary lies in the northern catchment of the Alaknanda river, which is the major tributary of the upper reaches of the Ganges. The sanctuary is bounded to the north by a range of peaks, mostly over 6,000 m, and in the south by the Mandal-Okhimath road (Fig. 1). Altitude ranges from 1,160 m (near Phata) to 7,068 m (Chaukhamba peak).

The climate is considerably influenced by the southwest monsoon in summer and by the passage of belts of low pressure, known as 'western disturbances', in winter (see Mani 1981). The sanctuary is fully exposed to the summer monsoon because its main valleys tend to lie in a N-S direction and there is very little rain-shadow effect from the 3,000 m high hill ranges to the south. Of the mean annual precipitation of 3,093 mm at 3,050 m in the main study area, 81% fell in the monsoon, between June and September, and 11% fell as snow in winter, between December and March (Green 1985). Temperatures are highest in May or June prior to the arrival of the monsoon, after which conditions become overcast, and lowest in the first half of January. The highest and lowest temperatures recorded at 3,050 m in the main study area were 25.0°C and —10.5°C, respectively (Green 1985). The sanctuary is snow-bound for about three months of the year, following heavy snowfalls in December.

A great variety of vegetation types occurs in the sanctuary, reflecting the complex and diverse nature of the climate, geology and topography in the region. The subtropical, temperate, subalpine and alpine zones are represented in the sanctuary but the tropical zone, which does not occur above 1,200 m, is absent. The major forest types, based on the classification of Champion and Seth (1968), are described by Agrawala (1973). For present purposes it is convenient to distinguish the following types of vegetation, all of which occur in the main study area.

SUBTROPICAL AND TEMPERATE ZONES

Ban/moru oak forest (1,500-2,750 m)

Ban oak (*Quercus incana*) or moru oak (*Q. dilatata*), at altitudes above 2,100 m, predominate with *Rhododendron arboreum* often constituting a second storey. Elm (*Ulmus wallichiana*), horsechestnut (*Aesculus indica*), bird-cherry (*Prunus padus*), hazel (*Corylus colurna*) and maple (*Acer* spp.), which are absent from the lower altitudes, are often associated with moru oak. Common shrubs include *Indigofera, Berberis, Rubus, Viburnum* and, in the case of moru oak forests, bamboo (*Thamnocalamus* spp.).

TEMPERATE ZONE

Karsu oak forest (2,500-3,300 m)

Karsu oak (*Q. semecarpifolia*) is usually associated with a second storey of *R. arboreum.* Other tree species may include fir (*Abies pindrow*), maple (*A. caecium*), *Meliosma dilleniaefolia,* rowan (*Sorbus lanata*) and yew (*Taxus baccata*). The understorey is dominated by impenetrable thickets of bamboo (*T. spathiflorus*) wherever undisturbed. Common shrubs include *Berberis, Cotoneaster, Rosa, Skimmea, Spiraea* and *Viburnum.*

Conifer forest (2,600-3,400 m)

Fir (*A. pindrow*) is predominent and often restricted to northern and sheltered slopes. *Rhododendron arboreum* mixed with karsu oak comprise a second canopy. The understorey is similar to that of karsu oak forest.

SUBALPINE ZONE

Birch-rhododendron scrub forest
(3,100-3,350 m)

This forest type occurs above the conifer and oak forests and fringes the alpine meadows. Birch (*Betula utilis*), the characteristic species, is sparsely distributed and does not form a complete canopy. *Prunus cornuta, Rhododendron arboreum, Sorbus foliolosa* and *Viburnum foetens* form a second storey. The understorey is dominated by extensive evergreen stands of *Rhododendron campanulatum*, frequently intermingled with clumps of bamboo (*T. spathiflorus*). Other common shrubs include *Cotoneaster, Rosa, Rubus* and *Spiraea.*

ALPINE ZONE

Rhododendron scrub (3,350-3,500 m)

Birch-rhododendron scrub forest grades into rhododendron scrub, chiefly *R. campanulatum*, above 3,350 m. Trees are absent but the composition of the shrub layer is similar to that of birch-rhododendron scrub forest.

Pasture (above 3,500 m)

The herb community is often dominated by *Danthonia cumminsii* which forms tussocks of grass over extensive areas. Small shrubs such as *Gaultheria nummularioides, G. trichophylla* and *Rhododendron lepidotum* are also present. Forbs are predominant in the vicinity of former kharaks (settlements temporarily used by herdsmen and shepherds), particularly nitrophilous species such as *Bistorta* spp., *Potentilla fulgens*, and *Selinum vaginatum.*

Large patches of forest within the temperate and subalpine zones have been cleared, over many decades, primarily for pasture and also for fuelwood. The grassland communities are maintained by regular burning in early spring and grazed by livestock (goats, sheep and water buffalo) during the summer months. Also grass is cut for fodder in autumn. More widespread is the considerable depletion of the forest understorey, particularly in the temperate zone. Bamboo and other resources that are valuable commodities are removed and subsequent grazing by livestock inhibits regeneration of the shrub layer.

SPECIES ACCOUNTS

The following is an annotated preliminary list of birds found in the Kedarnath Sanctuary. It is not comprehensive as many parts of the sanctuary were never visited. Moreover, some of the species that are difficult to identify in the field were undoubtedly overlooked. All records relate to the main study area unless a species was seen elsewhere, in which case all locations are given. Species not recorded by either Osmaston (1921), Lavkumar (1956) or Devillers (1976) are marked with an asterisk. The systematics and scientific nomenclature follow those of Ali and Ripley (1968-74); common names are taken from Fleming *et al.* (1976). The numbers in square brackets refer to the subspecies in Ali and Ripley. Information about seasonal status is based on Ali and Ripley, Fleming *et al.* and Inskipp and Inskipp (1985).

ACCIPITRIDAE

?*Pernis ptilorhynchus* Honey Buzzard [130]
3,290 m Resident
Probably seen once. Usually not recorded above 1,800 m (Ali and Ripley 1968), although Inskipp and Inskipp (1985) recorded a probable migrant at 3,050 m in May.

Green: Kedarnath Sanctuary

Above: The main study area lies at the southern edge of the Kedarnath Sanctuary, above the Mandal-Chopta Chatti Road (foreground). The peak (top left) is Chandrasila (3,680 m.)

Below: The Bearded Vulture *Gypaetus barbatus* is fairly common in the sanctuary.

(*Photos:* Author)

?*Milvus migrans* Dark Kite [134]
3,470 m Summer visitor
Probably seen once, perched on cliffs at Rudranath.

**Buteo sp.* Buteo [154]
3,050–3,660 m Resident
Fairly common, around oak-rhododendron forest and clearings. Dark patches on the carpels. The species is either *buteo, hemilasius* or *rufinus,* all of which are difficult to distinguish in the field. One seen on 5 June dropped its nesting material after being divebombed by another (R. T. Sauey pers. comm.). Once, in November, one seen being mobbed by at least nine jungle crows.

**Spizaetus nipalensis* Mountain Hawk-eagle [158]
3,050 m Resident
Scarce — seen once, perched on a rhododendron tree at the forest's edge. Elsewhere not recorded above 2,835 m (Inskipp and Inskipp 1985).

Aquila chrysaetos Golden Eagle [166]
2,130–3,350 m Resident
Occasional, above open forest and cliffs. Locals report that it hunts Impeyan Pheasant.

**Aquila nipalensis* Steppe Eagle [169]
1,680–3,660 m Winter visitor
Occasional, over open forest and cliffs.

Ictinaetus malayensis Black Eagle [172]
3,200 m Resident
Scarce — seen once, over forest.

Torgos calvus Black Vulture [178]
1,370–2,290 m Resident
Occasional, between Chopta Chatti and Okhimath and in Madhyamaheshwar valley.

Gyps himalayensis Himalayan Griffon Vulture [181]
1,680–3,660 m Resident
Common, over forest and cliffs in the main study area and near Kedarnath. One of two roosting sites, situated 40 m apart on some cliffs, was occupied by 1700 h on 17 June. The occupant rested thereafter despite being approached, at 1900 h, to within 15 m by marauding langurs (*Presbytis entellus*).

Gypaetus barbatus Bearded Vulture [188]
2,900–3,660 m Resident
Fairly common, in the vicinity of cliffs in the main study area and at Kedarnath and Rudranath. A pair seen copulating repeatedly on 8 October while perched on some cliffs.

Circus cyaneus Hen Harrier [189]
3,050–3,960 m Winter visitor and/or passage migrant
Fairly common, above the tree line. Males and females seen singly, usually in autumn and once in spring.

**Spilornis cheela* Crested Serpent Eagle [196]
1,830 m Resident
Probably occasional — seen once, between Chopta Chatti and Okhimath (R. T. Sauey pers. comm.).

FALCONIDAE

**Falco subbuteo* Eurasian Hobby [212]
3,350 m Winter visitor or resident
Scarce — seen once, perched on a rock at the edge of oak-rhododendron forest. May well breed in the area, as in western Nepal (Inskipp and Inskipp 1985).

Falco tinnunculus Eurasian Kestrel [222]
2,440–3,510 m Resident
Common, in forest clearings and by cliffs.

PHASIANIDAE

Lerwa lerwa Snow Partridge [227]
3,110–3,660 m Resident
Fairly common, on rocky and grassy slopes. Coveys of 5-20 birds recorded in winter, from late November until early April. Summer months spent above 3,660 m.

Tetraogallus himalayensis Himalayan Snowcock [232]
3,200 m Resident
Scarce — seen once, when two were sighted on a grassy slope above the tree line.

Francolinus francolinus Black Partridge [238]
1,830–1,950 m Resident
Fairly common, in the understorey of oak-rhododendron forest.

Arborophila torqueola Common Hill Partridge [267]
2,710–3,140 m Resident
Fairly common, in oak-rhododendron forest. Covey of two males and three females seen on 9 February. Female with several chicks seen on 28 June.

**Arborophila rufogularis* Rufous-throated Hill Partridge [270]
2,930–3,050 m Resident
Occasional, in oak-rhododendron forest amidst dense undergrowth. Previously not recorded above 2,400 m (Ali and Ripley 1969).

Lophophorus impejanus Impeyan Preasant [290]
2,470–3,690 m Resident
Common, in oak-rhododendron forest and on grassy slopes and cliffs above the tree line in the main study area, Kilpulbhadni, Madhyamaheshwar, Okhla Dhar, Rudranath and near Kedarnath. Two males observed fighting on 26 April. A nest with three eggs found under an overhanging rock on 27 April; a fourth egg laid by 28 April but the nest was subsequently deserted. A total of six females and 11-12 fledglings recorded in an area of about 1 km^2 during the first week of July (A. D. Lelliott pers. comm.). Personal observations suggest that the density of the population in the main study area was at least ten pairs km^{-2}.

Lophura leucomelana Kalij Pheasant [293]
1,520–2600 m Resident
Fairly common, in oak-rhododendron forest. Up to ten males and one female in May and eight males and six females in October recorded along an approximately 8 km stretch of road between Mandal and Pangarbasa.

Pucrasia macrolopha Koklas Pheasant [305/6]
2,100–3,350 m Resident
Fairly common, in oak-rhododendron forest and rhododendron scrub in the main study area, Kilpulbhadni and at Rudranath. Two males seen fighting in dense forest on 8 June (B. Breeden and R. T. Sauey pers. comm.). A female seen with six, possibly seven, fledglings on 17 June; another seen with six fledglings on 7 August. About five pairs km^{-2} in the main study area (Green unpublished data).

CHARADRIIDAE

Scolopax rusticola Woodcock [411]
3,050–3,380 m Summer visitor
Occasional, in oak-rhododendron forest. Sometimes seen 'roding' (see Ali and Ripley 1969) at dusk in June.

COLUMBIDAE

Columba leuconota Snow Pigeon [513]
2,800–3,050 m Resident
Fairly common, around cliffs. Considerable seasonal altitudinal movement — a flock of about 30 birds descended to 2,830 m in consecutive winters and roosted by some caves among cliffs.

Streptopelia orientalis Rufous Turtle Dove [531]
2,800 m Resident
Fairly common, on forest roads.

PSITTACIDAE

Psittacula himalayana Slatyheaded Parakeet [562]
1,680 m Resident
Occasional, in flocks in oak-rhododendron forest.

CUCULIDAE

**Cuculus sparverioides* Large Hawk-Cuckoo [572]
2,900–3,200 m Resident
Fairly common, in oak-rhododendron forest. Previously not recorded above 2,900 m (Fleming *et al.* 1976).

Cuculus canorus Eurasian Cuckoo [578]
3,050-3,660 m Summer visitor
Fairly common, in oak-rhododendron forest.

Cuculus saturatus Himalayan Cuckoo [580]
2,740–3,350 m Resident or summer visitor
Fairly common, in oak-rhododendron forest. Calls were heard for the first time in 1981 on 19 March. One of a pair seen collecting grass on 18 April.

STRIGIDAE

**Otus spilocephalus* Spotted Scops Owl [611]
3,050–3,200 m Resident
Common, in oak-rhododendron forest. Could be heard throughout the night during summer. Previously not recorded above 2,745 m (Fleming *et al.* 1976).

**Strix aluco* Tawny Wood Owl [662]
3,050 m Resident
Common, in oak-rhododendron forest. Never seen but calls recognised by S. and B. Breeden and R. T. Sauey (pers. comm.).

CAPRIMULGIDAE

Caprimulgus indicus Jungle Nightjar [670]
3,050–3,810 m Resident
Fairly common, at edge of oak-rhododendron forest or rhododendron scrub. A previously unrecorded call heard at dusk on 10 May and 28 June at Bisuri Tal while seen flying low over rhododendron scrub. This call also recorded by A.D. Lelliott (pers. comm.) who describes it as a series of 5-14 'chuck' calls, crescending in the middle of the sequence and diminishing towards the end. The call lasts for about five seconds and is often accompanied by a 'rushing of wind' note that usually terminates very abruptly. This note has been described as the 'whish-whish' of the wings of a powerful bird in flight (Osmaston 1921). Previously not recorded above 3,300 m (Ali and Ripley 1970).

APODIDAE

Collocalia brevirostris Edible Nest Swiftlet [683]
2,800–3,050 m Resident
Fairly common, seen on several occasions above ridges (S. Breeden pers. comm.).

Apus pacificus Large Whiterumped Swift [700]
3,050 m Resident
Fairly common, above ridges.

?*Apus affinis* House Swift [703]
3,050 m Resident
A probable sighting above cliffs by T. Milliken (pers. comm.). The species does not normally occur above 2,100 m (Inskipp and Inskipp 1985).

UPUPIDAE

**Upupa epops* Hoopoe [765]
1,830 m Resident
Scarce — seen once, on a forest road.

CAPITONIDAE

Megalaima virens Great Himalayan Barbet [777]
1,680–2,130 m Resident
Fairly common, in oak-rhododendron forest (S. Breeden pers. comm.).

PICIDAE

Picus squamatus Large Scalybellied Woodpecker [807]
2,180–3,220 m Resident

Fairly common, in oak-rhododendron forest and rhododendron scrub. Seen once on the snow-free part of some cliffs above the tree line, where the surrounding slopes were completely snow-covered.

**Picus canus* Blacknaped Woodpecker [809]
1,920-3,230 m Resident
Common, in oak-rhododendron forest and clearings in the main study area and at Ansuya Devi. Often on the ground, sometimes with Laughing Thrushes and once with White-collared Blackbirds. Previously not recorded above 2,440 m (Fleming *et al.* 1976).

**Hypopicus hyperythrus* Rufousbellied Sapsucker [833]
1,680–2,590 m Resident
Fairly common, in oak-rhododendron forest.

Dendrocopos himalayensis Himalayan Pied Woodpecker [837]
2,190–3,110 m Resident
Common, in oak-rhododendron forest. While drilling a hole in an oak tree (*Quercus semecarpifolia*) on 10 April, a female hid behind the far side of the trunk whenever a Jungle Crow flew past.

**Dendrocopos macei* Fulvousbreasted Pied Woodpecker [845]
1,950-2,040 m Resident
Fairly common, in oak-rhododendron forest.

HIRUNDINIDAE

Delichon urbica Eurasian House Martin [930/1]
3,260–3,630 m Summer visitor
Occasional, in flocks above cliffs in the main study area and at Rudranath.

LANIIDAE

Lanius schach Rufousbacked Shrike [947]
1,680 m Resident
Common, in open country around villages.

ORIOLIDAE

Oriolus traillii Maroon Oriole [961]
2,300–3,030 m Resident
Occasional, in oak-rhododendron forest. Previously not recorded above 2,440 m (Fleming *et al.* 1976).

Dicrurus leucophaeus Ashy Drongo [965]
1,680-2,040 m Resident
Fairly common, in the vicinity of forest. Adults seen feeding fledglings on 4 June (S. Breeden, pers. comm.).

STURNIDAE

Acridotheres tristis Common Myna [1006]
2,060 m Resident
Common, around the temple at Ansuya Devi.

**Acridotheres fuscus* Jungle Myna [1009]
1,680–1,830 m Resident
Fairly common. Pairs nesting in a tree hollow and among rocks along a forested roadside on 4 June; one parent fed young with a skink (S. Breeden pers. comm.).

CORVIDAE

Garrulus glandarius Eurasian Jay [1020]
1,800–3,200 m Resident
Fairly common, in oak-rhododendron forest in the main study area and at Ansuya Devi. Previously not recorded above 2,740 m (Fleming *et al.* 1976).

Garrulus lanceolatus Blackthroated Jay [1022]
1,830 m Resident
Probably occasional — seen once, between Chopta Chatti and Okhimath (R.T. Sauey pers. comm.).

Cissa flavirostris Yellowbilled Blue Magpie [1025]
1,680–3,080 m Resident
Common, in oak-rhododendron forest. Two fledglings seen learning to fly on 30 June. Seve-

ral birds seen mobbing a Himalayan yellow-throated marten (*Martes flavigula*) on 20 March.

Dendrocitta formosae Himalayan Tree Pie [1037]
1,680–1,830 m Resident
Common, in cultivated fields and forest.

Nucifraga caryocatactes Nutcracker [1043]
3,050 m Resident
Scarce — seen once, in oak-rhododendron forest in the main study area (S. Breeden pers. comm.).

Pyrrhocorax pyrrhocorax Redbilled Chough [1047]
3,140–3,510 m Resident
Fairly common, among cliffs in the main study area and near Rudranath and Kedarnath.

Corvus macrorhynchos Jungle Crow [1054]
2,800–3,720 m Resident
Common, in forest and above the tree line. Fledgling seen learning to fly on 2 June. Parents observed feeding two young with chapattis on 14 July. Once several birds seen repeatedly divebombing a male Impeyan Pheasant, which was feeding, but they did not mob its mate just 30 m away.

CAMPEPHAGIDAE

Pericrocotus ethologus Longtailed Minivet [1085]
1,680–3,200 m Resident
Common, in oak-rhododendron forest.

PYCNONOTIDAE

Pycnonotus leucogenys Whitecheeked Bulbul [1125]
1,680 m Resident
Common, in oak-rhododendron forest.

Pycnonotus cafer Redvented Bulbul [1131]
1,680 m Resident
Fairly common, in oak-rhododendron forest in the main study area and at Ansuya Devi.

MUSCICAPIDAE

Pomatorhinus erythrogenys Rustycheeked Scimitar Babbler [1182]
2,040 m Resident
Scarce — seen once, in secondary scrub bordering cultivated fields at Ansuya Devi.

**Pnoepyga albiventer* Scalybreasted Wren-Babbler [1197]
3,050–3,190 m Resident
Occasional, in bamboo thickets.

?*Stachyris chrysaea* Golden-headed Babbler [1212]
2,440 m Resident
Probably seen once, in oak-rhododendron forest between Chopta Chatti and Okhimath (S. Breeden, pers. comm.). Previously not recorded west of Central Nepal (Ali and Ripley 1971, Fleming *et al.* 1976).

**Paradoxornis nipalensis* Nepal Parrotbill [1239a]
3,000–3,150 m Resident
Occasional, among rhododendron and bamboo thickets in oak forest. Previously not recorded above 3,000 m (Inskipp and Inskipp 1985).

Garrulax albogularis Whitethroated Laughing Thrush [1273]
1,680–2,440 m Resident
Common, in oak-rhododendron forest and clearings. Seen in parties of up to 30 in the main study area and at Ansuya Devi.

Garrulax striatus Striated Laughing Thrush [1279]
1,680–3,260 m Resident
Common, in oak-rhododendron forest. Considerable seasonal altitudinal movement — seen just below the snow line at 2,130 m on 12 January. Previously not recorded above 2,850 m (Inskipp and Inskipp 1985).

Garrulax variegatus Variegated Laughing Thrush [1290]
2.800–3,280 m Resident

Common, in oak-rhododendron forest in parties of up to five.

***Garrulax ocellatus* Whitespotted Laughing Thrush [1298]
2,900–3,080 m Resident
Fairly common, in oak-rhododendron forest.

Garrulax lineatus Streaked Laughing Thrush [1314]
2,040–3,230 m Resident
Fairly common, in oak-rhododendron forest and clearings in the main study area and at Ansuya Devi.

Garrulax erythrocephalus Redheaded Laughing Thrush [1324]
2,040–3,290 m Resident
Common, in oak-rhododendron forest in the main study area and in cultivated fields at Ansuya Devi.

Minla strigula Barthroated Minla [1358]
3,050–3,280 m Resident
Common, among bamboo thickets in oak-rhododendron forest.

Yuhina gularis Stripethroated Yuhina [1371/2]
2,350–3,290 m Resident
Fairly common, in oak-rhododendron forest and birch-rhododendron scrub. Seen in parties of up to a dozen in the main study area and near Kedarnath.

Alcippe vinipectus Whitebrowed Tit-Babbler [1380]
2,900–3,570 m Resident
Common, in scrub.

Heterophasia capistrata Blackcapped Sibia [1396]
2,130–2,590 m Resident
Common, in oak-rhododendron forest.

Muscicapa sibirica Sooty Flycatcher [1406]
3,050–3,200 m Summer visitor
Fairly common, at the edge of clearings in oak-rhododendron forest in the main study area and at Kilpulbhadni.

**Muscicapa strophiata* Orangegorgetted Flycatcher [1414]
2,590–3,080 m Resident
Common, in oak-rhododendron forest.

**Muscicapa westermanni* Little Pied Flycatcher [1419]
3,080–3,200 m Summer visitor
Occasional, in oak-rhododendron forest. Previously not recorded west of Nepal or above 3,000 m (Inskipp and Inskipp 1985).

Muscicapa superciliaris Whitebrowed Blue Flycatcher [1421]
2,440–2,530 m Resident
Fairly common, in oak-rhododendron forest and clearings.

Muscicapa leucomelanura Slaty Blue Flycatcher [1423]
3,200 m Resident
Occasional, close to the ground in bamboo thickets.

**Muscicapa sundara* Beautiful Niltava [1432]
1,680–3,200 m Resident
Fairly common, in oak-rhododendron forest.

Muscicapa thalassina Verditer Flycatcher [1445]
2,130-3,200 m Summer visitor
Common, in tree tops at the edge of clearings in the main study area and "at Kilpulbhadni."

Culicicapa ceylonensis Greyheaded Flycatcher [1448]
1,950-3,050 m Summer visitor
Fairly common, in oak-rhododendron forest.

Rhipidura hypoxantha Yellowbellied Fantail Flycatcher [1450]
2,100–3,280 m Resident
Fairly common, in oak-rhododendron forest.

Cettia brunnifrons Rufouscapped Bush Warbler [1486]
2,040-3,350 m Resident
Common, in rhododendron bushes and bamboo thickets.

Bradypterus thoracicus Spotted Bush Warbler [1490]

3,110–3,230 m Resident

Common, in pastures. Three nests, lined with grass and feathers and containing 3-4 eggs, found 10-40 m apart in grass tussocks (A.D. Lelliott pers. comm.).

Phylloscopus inornatus Plain Leaf Warbler [1590]

3,050 m ?Summer visitor

Probably common but seen only once by A.D. Lelliott (pers. comm.).

**Phylloscopus maculipennis* Greyfaced Leaf Warbler [1597/8]

3,110-3,200 m Resident

Fairly common, in open oak-rhododendron forest.

**Phylloscopus magnirostris* Largebilled Leaf Warbler [1601]

3,510 m ?Summer visitor

Probably fairly common but seen only once, at Rudranath.

Phylloscopus trochiloides Dull Green Leaf Warbler [1604]

3,350 m ?Summer visitor

Probably fairly common but seen only once, in rhododendron scrub at Rudranath.

**Phylloscopus reguloides* Crowned Leaf Warbler [1609]

2,800–3,410 m Resident

Common, in open oak-rhododendron forest and rhododendron scrub. A nest, containing four chicks with their eyes closed, found in a hole on a 45° slope on 29 May. A fifth chick lay dead outside the nest. One chick had its eyes open by 2 June. The chicks were last seen on 6 June and the nest was empty by 14 June.

Siecercus burkii Yellow-eyed Warbler [1614/5]

2,990–3,410 m Summer visitor

Fairly common, in rhododendron scrub.

Seicercus xanthoschistos Greyheaded Warbler [1616]

3,110–3,630 m Resident

Fairly common, in oak-rhododendron forest and above the tree line. Previously not recorded above 2,700 m (Ali and Ripley 1973).

**Seicercus poliogenys* Greycheeked Warbler [1620]

3,110–3,260 m Resident

Scarce, in rhododendron scrub. Previously not recorded west of Central Nepal or above 3,200 m (Inskipp and Inskipp 1985).

**Brachypteryx stellata* Gould's Shortwing [1635]

3,540 m Resident

Scarce — seen once, in rhododendron scrub at Rudranath.

Erithacus cyanurus Orangeflanked Bush Robin [1654]

2,040–3,280 m Resident

Common, in oak-rhododendron forest, rhododendron scrub and clearings. Nest with at least two chicks discovered in a hole on a 45° grass slope on 30 May. It was subsequently found, on 17 June, strewn outside the hole with one unhatched egg (18 x 13 mm). Nest made of grass, lined inside with moss and the hairs of musk deer (2,762 hairs counted by S. Breeden).

**Erithacus indicus* Whitebrowed Bush Robin [1659]

3,110–3,350 m Resident

Occasional, in oak-rhododendron forest and rhododendron scrub in the main study area and at Rudranath.

Phoenicurus caeruleocephalus Blueheaded Redstart [1670]

2,440–3,200 m Resident

Fairly common, in forest clearings and rhododendron scrub.

Phoenicurus frontalis Bluefronted Redstart [1675]

3,350–3,510 m Resident

Fairly common, in open scrub. Male seen gathering food for young nesting in cliffs on 5 June (S. Breeden, pers. comm.).

Rhyacornis fuliginosus Plumbeous Redstart [1679]
1,980–2,350 m Resident
Occasional, by fast flowing streams. Seen along the Balasuti Nala, north of Mandal, and near Ansuya Devi.

**Grandala coelicolor* Grandala [1683]
3,960 m Resident
Scarce — seen once, a pair on rocky slopes near Bisuri Tal on 8 June (S.M.C. Poulton pers. comm.).

Enicurus scouleri Little Forktail [1684]
1,830–3,280 m Resident
Common, by streams in closed and open habitat.

**Enicurus immaculatus* Blackbacked Forktail [1685]
1,830–2,130 m Resident
Occasional, by streams in forest. Previously not recorded above 1,450 m (Ali and Ripley 1973).

Enicurus maculatus Spotted Forktail [1688]
1,830–3,050 m Resident
Fairly common, by streams.

Chaimarrornis leucocephalus Whitecapped River Chat [1716]
1,830–3,510 m Resident
Common, along fast flowing streams and rivers. Two pairs building nests on 5 June (S. Breeden pers. comm.). Flightless chicks in a nest on 6 July; two fledglings seen flying with adults on 7 July (A.D. Lelliott pers. comm.).

Monticola cinclorhynchus Blueheaded Rock Thrush [1723]
3,110 m Summer visitor
Scarce — seen once by R. T. Sauey (pers. comm.).

Monticola rufiventris Chestnutbellied Rock Thrush [1724]
2,740–3,290 m Resident
Fairly common, in oak-rhododendron forest and rhododendron scrub.

Monticola solitarius Blue Rock Thrush [1726]
3,140–3,200 m Resident
Scarce, near water in rhododendron scrub.

Myiophonus caeruleus Whistling Thrush [1729]
1,830–3,350 m Resident
Occasional, by rivulets in forest.

**Zoothera dixoni* Longtailed Mountain Thrush [1740]
3,440 m Resident
Scarce — seen once by A. D. Lelliott (pers. comm.).

Zoothera dauma Speckled Mountain Thrush [1741]
3,050 m Resident
Fairly common, in oak-rhododendron forest.

Zoothera monticola Large Longbilled Thrush [1745]
3,050–3,140 m Resident
Scarce — seen once, near a rivulet in rhododendron scrub.

**Turdus unicolor* Tickell's Thrush [1748]
2,740 m Summer visitor
Scarce — seen once, in oak-rhododendron forest.

Turdus albocinctus Whitecollared Blackbird [1749]
2,040–3,350 m Resident
Common, in oak-rhododendron forest and birch-rhododendron scrub in the main study area and at Rudranath and Ansuya Devi. Some seasonal altitudinal movement — a flock seen on the ground just below the snow line at 2,130 m on 12 January. Nest, lined with moss and containing two eggs, found in a tree hollow, 1.2 m above ground level (A. D. Lelliott pers. comm.).

Turdus boulboul Greywinged Blackbird [1750]
2,130–2,190 m Resident
Fairly common, in oak-rhododendron forest.

**Turdus merula* Eurasian Blackbird [1752]
1,830–3,460 m Resident
Occasional, in oak-rhododendron forest in the main study area and between Rambara and Kedarnath.

Turdus rubrocanus Greyheaded Thrush [1758]
2,130 m Resident
Scarce — seen once, amidst a flock of White-collared Blackbirds in oak-rhododendron forest.

**Turdus ruficollis* Blackthroated Thrush [1763]
3,230 m Winter visitor
Occasional — seen once, a party of at least six in rhododendron scrub.

Turdus viscivorus Mistle Thrush [1768]
2,740–3,170 m Resident
Fairly common, in oak-rhododendron forest and forest clearings.

TROGLODYTIDAE

Troglodytes troglodytes Wren [1771]
2,830–3,200 m Resident
Occasional, in forest clearings and rhododendron scrub.

CINCLIDAE

Cinclus pallasii Brown Dipper [1775]
2,350–3,200 m Resident
Occasional, along fast flowing streams and rivers.

PRUNELLIDAE

Prunella collaris Alpine Accentor [1778/9]
2,380–3,170 m Resident
Fairly common, on cliffs and by the roadside. Seen below the tree line only in January and February.

**Prunella himalayana* Altai Accentor [1780]
3,310–3,440 m Winter visitor
Occasional, in flocks on grassy slopes. Seen in the main study area only between late March and mid-May.

PARIDAE

Parus monticolus Greenbacked Tit [1799]
2,040–3,170 m Resident
Fairly common, in oak-rhododendron forest in the main study area and at Ansuya Devi.

Parus melanolophus Spotwinged Black Tit [1802]
2,800–3,140 m Resident
Common, in oak-rhododendron forest.

**Parus rubidiventris* Rufousbreasted Black Tit [1805]
3,050–3,410 m Resident
Common, in oak-rhododendron forest and rhododendron scrub. The presence of grey on the rufous breast and belly suggests a transition form. Possibly the species hybridises with *P. rufonuchalis* (Simla Black Tit).

**Parus dichrous* Crested Brown Tit [1807/8]
2,830–3,170 m Resident
Common, in oak-rhododendron forest.

Parus xanthogenys Yellowcheeked Tit [1809]
1,680 m Resident
Probably occasional — seen once by A. D. Lelliott (pers. comm.).

Aegithalos concinnus Redheaded Tit [1818]
1,680–2,100 m Resident
Fairly common, in scrub.

Aegithalos niveogularis Whitethroated Tit [1822]
3,410 m Resident
Occasional, a party of about a dozen seen in rhododendron scrub.

SITTIDAE

Sitta himalayensis Whitetailed Nuthatch [1834]
3,050 m Resident

Fairly common, in oak-rhododendron forest.

Tichodroma muraria Wall Creeper [1839]
1,520–3,350 m Resident
Occasional, on cliffs. A bird in summer plumage, with a black throat, seen on 29 March.

CERTHIIDAE

Certhia familiaris Northern Tree Creeper [1843]
2,590–3,050 m Resident
Fairly common, in oak-rhododendron forest.

Certhia nipalensis Nepal Tree Creeper [1851]
3,050–3,140 m Resident
Fairly common, in oak-rhododendron forest. Previously not recorded west of Nepal (Inskipp and Inskipp 1985).

MOTACILLIDAE

Anthus hodgsoni Hodgson's Tree Pipit [1852/3]
2,800–3,310 m Resident
Common, around forest clearings. Flies to tops of tree when disturbed and pumps its tail. Solitary individuals often seen in winter.

Anthus roseatus Rosebreasted Pipit [1865]
3,200–3,660 m Summer visitor
Fairly common, in pastures.

Anthus sylvanus Upland Pipit [1873]
3,050 m Resident
Probably occasional — seen once by A. D. Lelliott (pers. comm.).

Motacilla caspica Grey Wagtail [1884]
1,830–2,740 m Summer visitor
Occasional, on forest road in the main study area and river terraces near Kedarnath.

Motacilla alba Pied Wagtail [1887]
3,510 m Summer visitor
Scarce — seen once, near Kedarnath.

NECTARINIIDAE

**Aethopyga nipalensis* Nepal Sunbird [1922]
3,050–3,150 m Resident
Occasional, in oak-rhododendron forest.

**Aethopyga ignicauda* Firetailed Sunbird [1930]
3,050–3,470 m Resident
Occasional, in oak-rhododendron forest. A male seen feeding from *Rhododendron arboreum* flowers on 29 March.

PLOCEIDAE

Passer domesticus House Sparrow [1939]
1,680 m Resident
Common, around villages.

FRINGILLIDAE

Mycerobas affinis Allied Grosbeak [1983]
2,900–3,140 m Resident
Occasional, in oak-rhododendron forest in the main study area and at Kilpulbhadni.

Carduelis carduelis Eurasian Goldfinch [1989]
1,520–3,290 m Resident
Fairly common, seen on several occasions by A. D. Lelliott (pers. comm.).

Leucosticte nemoricola Hodgson's Mountain Finch [2000]
2,040–3,350 m Resident
Occasional, on grassy slopes in the main study area. Flock of about 100 seen at Ansuya Devi.

**Carpodacus nipalensis* Nepal Rosefinch [2014/5]
3,050–3,350 m Resident
Fairly common, in open scrub and pastures.

Carpodacus rhodochrous Pinkbrowed Rosefinch [2017]
3,350 m Resident
Occasional, in rhododendron scrub. Males seen singly, or in twos, and females in parties of up to a dozen at Rudranath on 21 June.

**Carpodacus thura* Whitebrowed Rosefinch [2020/1]
3,050 m Resident
Occasional, in pastures.

Carpodacus puniceus Redbreasted Rosefinch [2030]
3,170–3,200 m Resident
Occasional, in open scrub.

**Haematospiza sipahi* Scarlet Finch [2034]
3,000 m Resident
Scarce — a pair seen once, in the tops of a fir (*Abies pindrow*).

Pyrrhula erythrocephala Redheaded Bullfinch [2039]
3,170–3,510 m Resident
Fairly common, in birch-rhododendron scrub in the main study area and near Kedarnath.

EMBERIZIDAE

Emberiza cia Rock Bunting [2052]
1,980–2,440 m Resident
Common, in forest clearings.

Melophus lathami Crested Bunting [2060]
1,680 m Resident
Common, in cultivated fields.

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Stanley and Belinda Breeden, Tony Lelliott and Ron Sauey kindly contributed information on a number of species. I am also very grateful to Stanley Breeden, Tim Inskipp, Tony Lelliott and Derek Lees-Smith for commenting on earlier drafts of the manuscript.

TABLE 1

WEIGHTS (KG) AND MEASUREMENTS (CM) OF GAME BIRDS CAUGHT IN BOX TRAPS IN THE MAIN STUDY AREA

Species	Date	Age Sex	Weight	Wing	Tail	Bill	Tarsus, middle toe and claw
Lophophorus	3.7.81	Ad. M*	2.3	30	23	4.8	15.2 cm
impejanus	27.8.81	Imm.	0.8	31	—	3.8	12.5 cm
Arborophila torqueola	13.6.81	Ad. M	—	14	4	2.5	11.0 cm
Scolopax rusticola	21.6.81	Ad. —	—	18	5–6	7.5	8.7 cm

* Crest measured 8.6 cm.

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TAXONOMIC STUDIES ON THE MARINE OSTRACODA FROM INDIA. FAMILY: LEPTOCYTHERIDAE HANAI, 1957[1]

C. ANNAPURNA AND D. V. RAMA SARMA[2]

(*With five plates*)

INTRODUCTION

Although several publications are available on the systematics and ecology of benthic ostracods from other countries, there is no comprehensive work either on taxonomy or ecology of marine and estuarine ostracods from India. Some information is available on the systematics of ostracods from the Miocene, Pliocene and Holocene sediments.

While investigating the systematics and ecology of benthic ostracods, 40 species belonging to 27 genera and 14 families were identified from the marginal marine environments namely Bimili backwaters (17°54′N, 83°28′E), Balacheruvu tidal stream (17°39′N, 83°15′E) and Vasishta Godavari estuary (16°18′N, 81°42′E).

Among the members of the family Leptocytheridae Hanai, 1957, *Leptocythere andhraensis, Tanella estuarii* and *T. kingmai* are new to science, *Callistocythere* sp. aff. *C. crispata* is found to be the first record from Indian waters. *T. vasishta* Annapurna & Rama Sarma 1979 and *T. indica* Annapurna & Rama Sarma 1979 were described earlier from the lower reaches of the Vasishta Godavari estuary and the marginal water bodies on the east coast of India (Annapurna & Rama Sarma, 1979a; 1979b)

MATERIAL AND METHODS

Regular sampling of the bottom sediments was made at monthly intervals with a core-device developed by Phleger (1960). The material was strained through a large sieve of 250 microns mesh size. The material was carefully washed and the rolled up sediment was gently broken up into fine sediment fractions with a brush. After the fine sediment was thus washed away, the specimens were transferred to a counting dish. The material was examined under a stereo binocular microscope and the forms were picked up with a double zero brush. After establishing their identity, the total number was counted and categorised as living and dead. The adults were dissected under glycerine and the appendages were sketched under camera lucida. The shells were mounted on microfossil slides.

RESULTS AND DISCUSSION

1. Genus *Leptocythere* Sars, 1928

Key for identification

1. Carapace elongated and subquadrangular and smooth .... *L. pellucida*
2. Carapace oblong and subreniform, surface ornamented with closely indistinct pits . . *L. macallana*
3. Carapace oval and quadrangular and marked with closely set, sharply defined, round, pits... .... *L. castanea*

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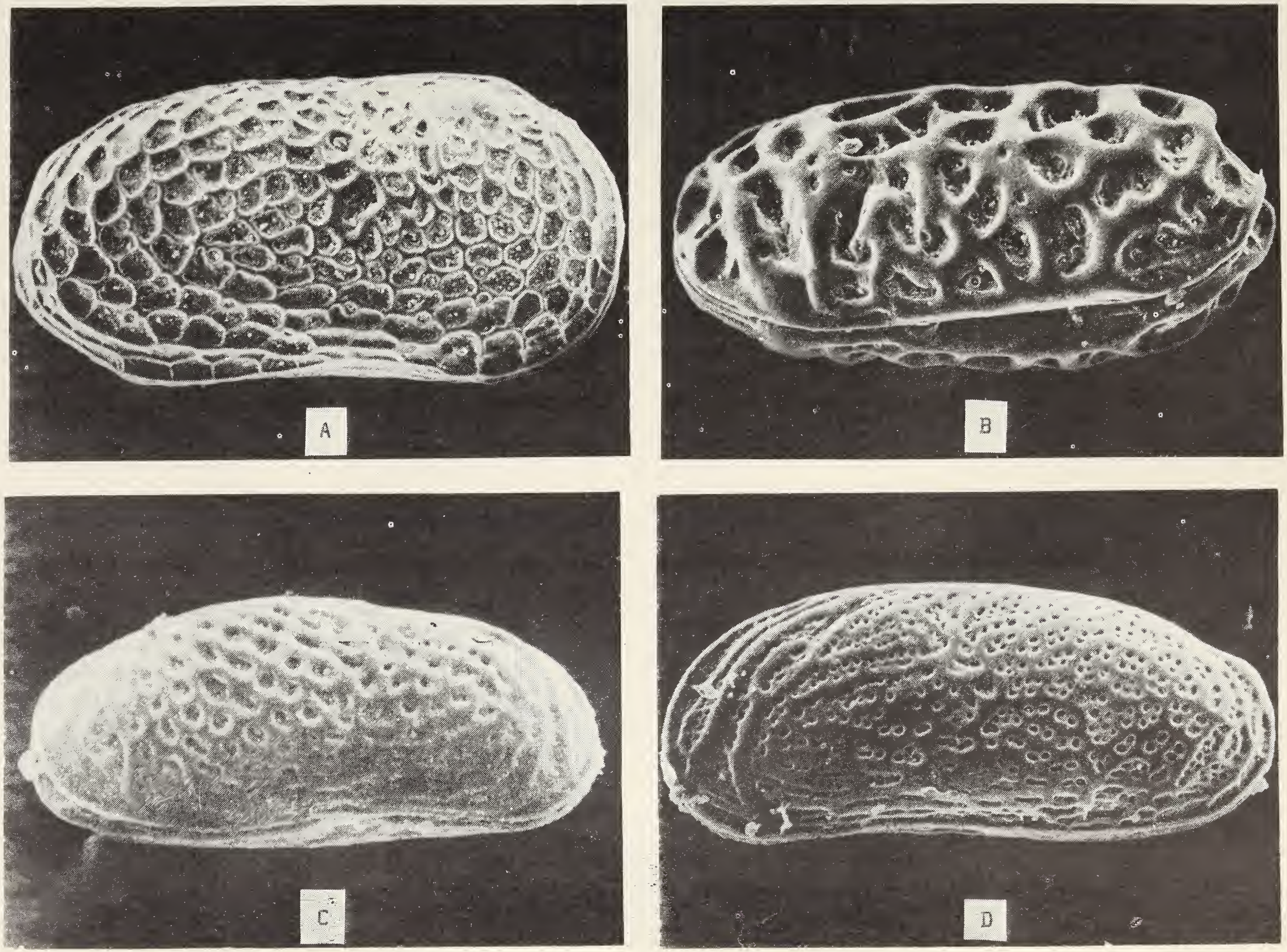


A. *Leptocythere andhraensis*—exterior view of complete shell; B. *Callistocythere* sp. aff. *C. crispata*—exterior view of complete shell; C. *Tanella estuarii*—dorsal view of carapace; D. *Tanella kingmai*—exterior view of carapace.

4. Carapace narrow, elongated and ornamented with few tubercles .... *L. tenera*
5. Carapace oval and subreniform and ornamented with elevated ridges .... *L. crispata*
6. Carapace oblong, elongated carapace, ornamented with dense pits .... *L. andhraensis*

Leptocythere andhraensis sp. nov. (Plate 1, A; Plate 2, A & B; Plate 3, 1-9)

Carapace oblong and moderately elongated, compressed laterally. Anterior end broadly rounded, posterior end truncated above, rounded below. Surface ornamented with dense pits. Hinge in the right valve antimerodont type; posterior sockets crenulate with crenulation of median hinge bar. The median hinge bar strongly crenulated in the left valve. Inner lamella wider anteriorly and narrower posteriorly and posteroventrally. Marginal pore canals straight and simple. Dorsal and ventral margins straight. Normal pores moderate in number and small. Central muscle scars in a vertical row of four and V-shaped frontal scar. Eye spot absent, left valve slightly larger than right.

Length: 0.57 mm; *Height*: 0.27 mm.

Antennule 3-jointed, ultimate podomere narrow and elongated and bears five claw-like setae. First claw-like seta divided into two setae. Antenna 3-jointed, penultimate podomere consists of slender setae; ultimate podomere with two pairs of claw-like setae. Spinneret seta 2-jointed, reaching the distal ends of claws. Mandible consists of one pair of long and three pairs of short teeth; mandibular palp 3-segmented and ends with five slender setae. Maxilla with masticatory lobes narrow and elongated and bears three elongated claw-like setae and five small setae. Vibratory plate wide with 13 unfeathered elongated rays. Thoracic legs 4-jointed ending with curved claws. Distal ends of each podomere with 1 to 3 setae. Palp-like structure developed on the first thoracic leg.

Remarks: In hingement, marginal pore canals and muscles scars *L. andhraensis* resembles *L. pellucida, L. macallana, L. castanea, L. tenera* and *L. crispata.* This species differs from the above species in (oblong and elongate) shape and densely pitted ornamentation. In the antennule, each claw-like seta is divided into two.

Type-locality: Bimili backwaters on the east coast of India.

Type-specimens: Holotype and two paratypes are deposited in the Museum of Zoological Survey of India, Calcutta, India.

Occurrence: Bimili backwaters and Vasishta Godavari estuary.

The species is named after Andhra Pradesh, the state in which both the localities are situated.

2. Genus *Callistocythere* Ruggieri, 1953

Callistocythere sp. aff. **C. crispata** (Brady, 1868) (Plate 1, B)

Cythere crispata Brady, 1868, pp. 72-73, pl. xiv, figs. 8a-d.

Shape elongated to subquadrangular; compressed laterally. Maximum height generally equal to half the length at the anterior end. Valves heavily calcified. Dorsal margin nearly straight. Posterodorsal cardinal angle prominent. Anterior end more broadly rounded than the posterior one. Ventral margin sinuous in the anterior half. Ornamentation strongly reticulate. Anterior and posterior marginal ridges well developed. Antero-ventral marginal and postero-ventral denticulation clear. Hinge amphidont/archidont type. Inner lamella wide in anterior and postero-ventral area. Line of concrescence almost coincides with the inner margins; anterior vestibulum poorly developed; selvage near and parallel to outer margin but in the posterior part often considerably removed removed from it. The left valve has a selvage-like ridge with a 'snap-pit on its outer side, situated at the sinuous margin, corresponds to 'snap-knob' in the right valve. Marginal pore canals less numerous, most wide at the base, typically branching. Normal pores moderate in number and open. A row of four adductor scars and one fulcral point present. Eye spot very weak. Left valve larger than right.

Length: 0.51 mm; Height: 0.34 mm.

Occurrence: Bimili backwaters; Balacheruvu tidal stream; Vasishta Godavari estuary.

3. Genus *Tanella* Kingma, 1948

KEY FOR IDENTIFICATION

1.	Shape of carapace elongate and narrow	3, 6
2.	Carapace oblong and tumid	7
3.	Hexagonal network with a prominent ridge	9
4.	Reticulated, longitudinal ridges strong and arched	11
5.	Pits separate and limited in number	*T. estuarii*
6.	Pits in clusters and innumerable	*T. kingmai*
7.	Posterior reticulation clear with 4 to 5 pits	*T. miurensis*
8.	Posterior reticulation obscure with 3 to 6 pits arranged in groups	13
9.	Socket in right valve crenulate	12
10.	Socket in right valve smooth	11, 13
11.	Marginal pore canals polyfurcate	*T. gracilis*
12.	Marginal pore canals bifurcate	*T. vasishta*
13.	Marginal pore canals intermediate between polyfurcate and bifurcate branching	*T. indica*

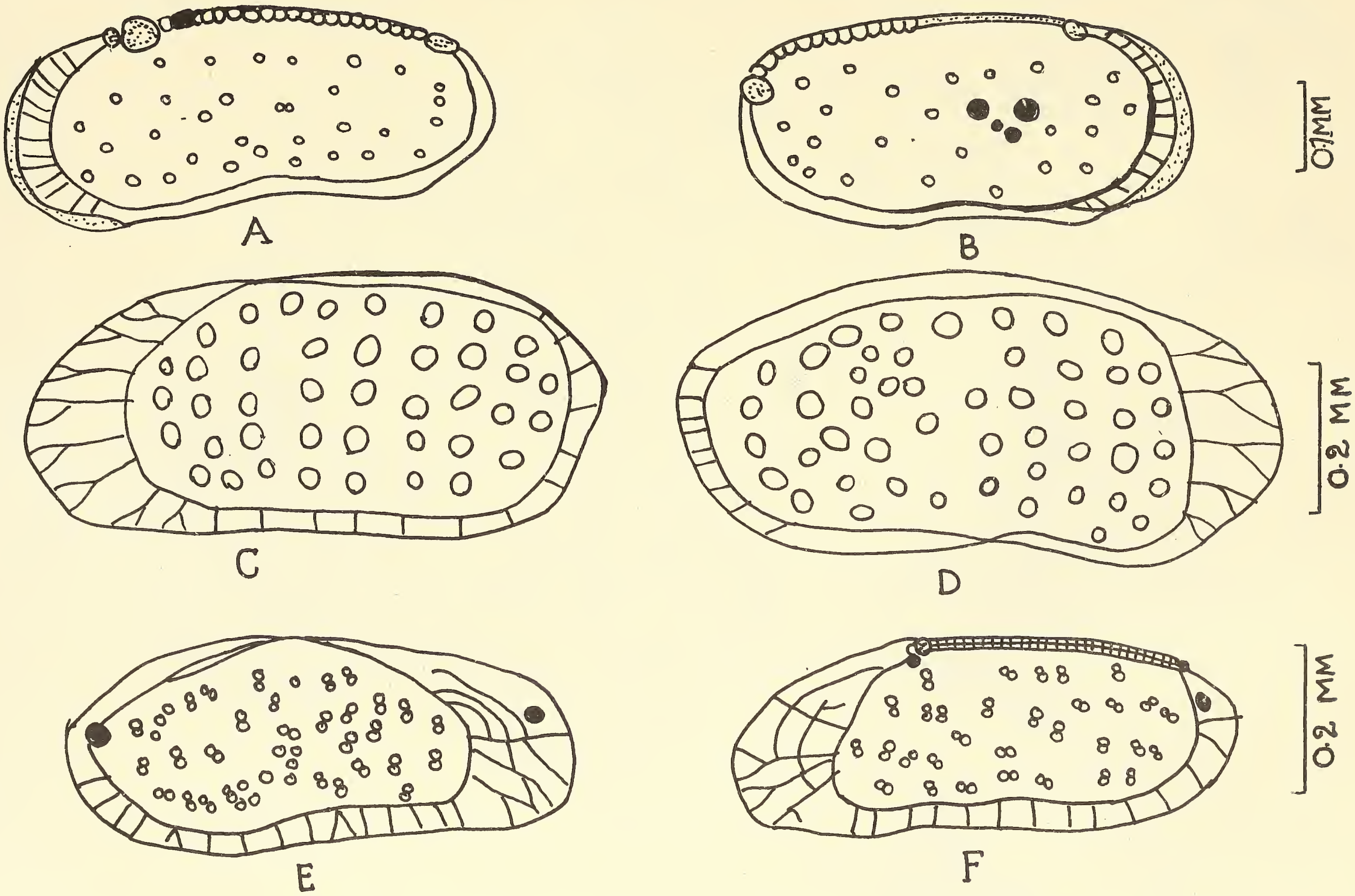
3a. **Tanella estuarii** sp. nov. (Plate 1, C; Plate 2, C & D; Plate 4, 1-10)

Carapace thin oblong and tumid in outline. Anterior margin obliquely rounded. Dorsal margin nearly straight inclined towards the posterior. Ventral margin straight sinuous at the anterior end. Posterior end truncated above and rounded below. Surface sculptured by strong vertical ridges at anterior and posterior ends. Pits arranged in rows. Anterior marginal ridges strong beginning at anterior cardinal angle and ending in anteroventral area. Posterior marginal ridges strong, beginning in posterior part of dorsal margin and extending to postero-ventral area and become straight and run parallel to ventral margin to ventral sinuous area. Hinge structure and adductor scars same as in type genus. Viewed from above, carapace ovate; with anterior and posterior marginal ridges projecting. Sexual dimorphism very strong. Male form more elongated than female. Posterior end broad in female for keeping eggs in brood cavity.

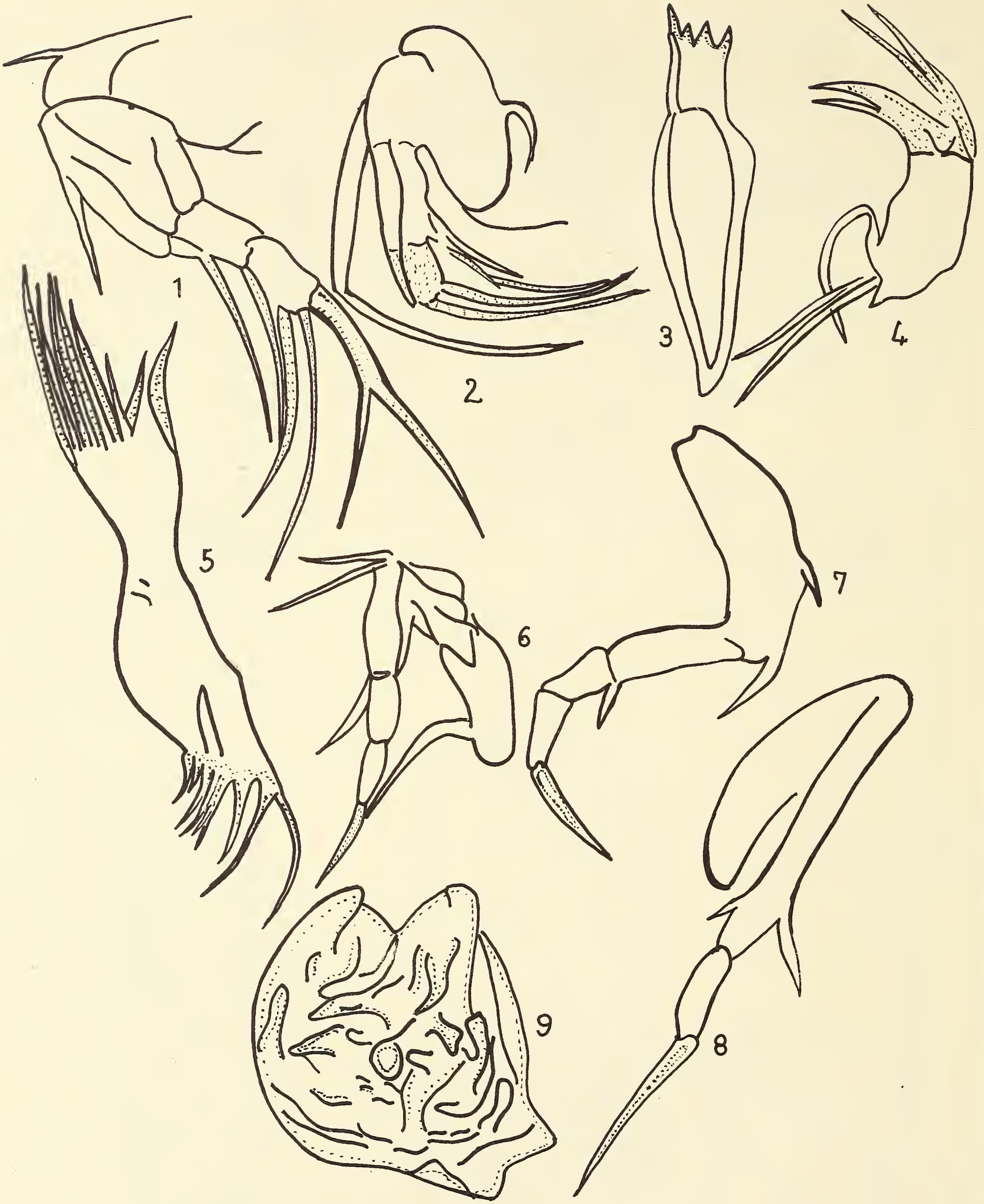
Length: 0.33 mm; *Height*: 0.17 mm.

Antennule 4-jointed, first two podomeres as long as the remaining two podomeres. Third podomere with dorsal claw-like setae and ultimate podomere with three stout distal claws. Antenna 4-jointed, second podomere twice the length of third podomere. Third podomere bears two setae on either side. The ultimate podomere consists of one seta at the anterior side and ends with two stout distal claws. Mandible with three serrate teeth laterally placed on cutting area. Mandibular palp 4-segmented. The first segment bulbous, second segment more elongated than the remaining one. Third segment bears two elongate setae. Fourth segment ends with five strong claws. Maxilla with three narrow masticatory lobes, the basal part slightly curved, terminate downwards in three short cylindrical rows. Jointed masticatory process and palp built of two podomeres. The masticatory process ends with setae. The exopodite well developed in the maxilla as a branchial plate or vibratory plate bearing 11 unfeathered rays. In thoracic legs, endopodite well developed protopodite 3-segmented ends with curved claws. Third thoracic leg directed downwards. Paired furcae attached to

PLATE 2

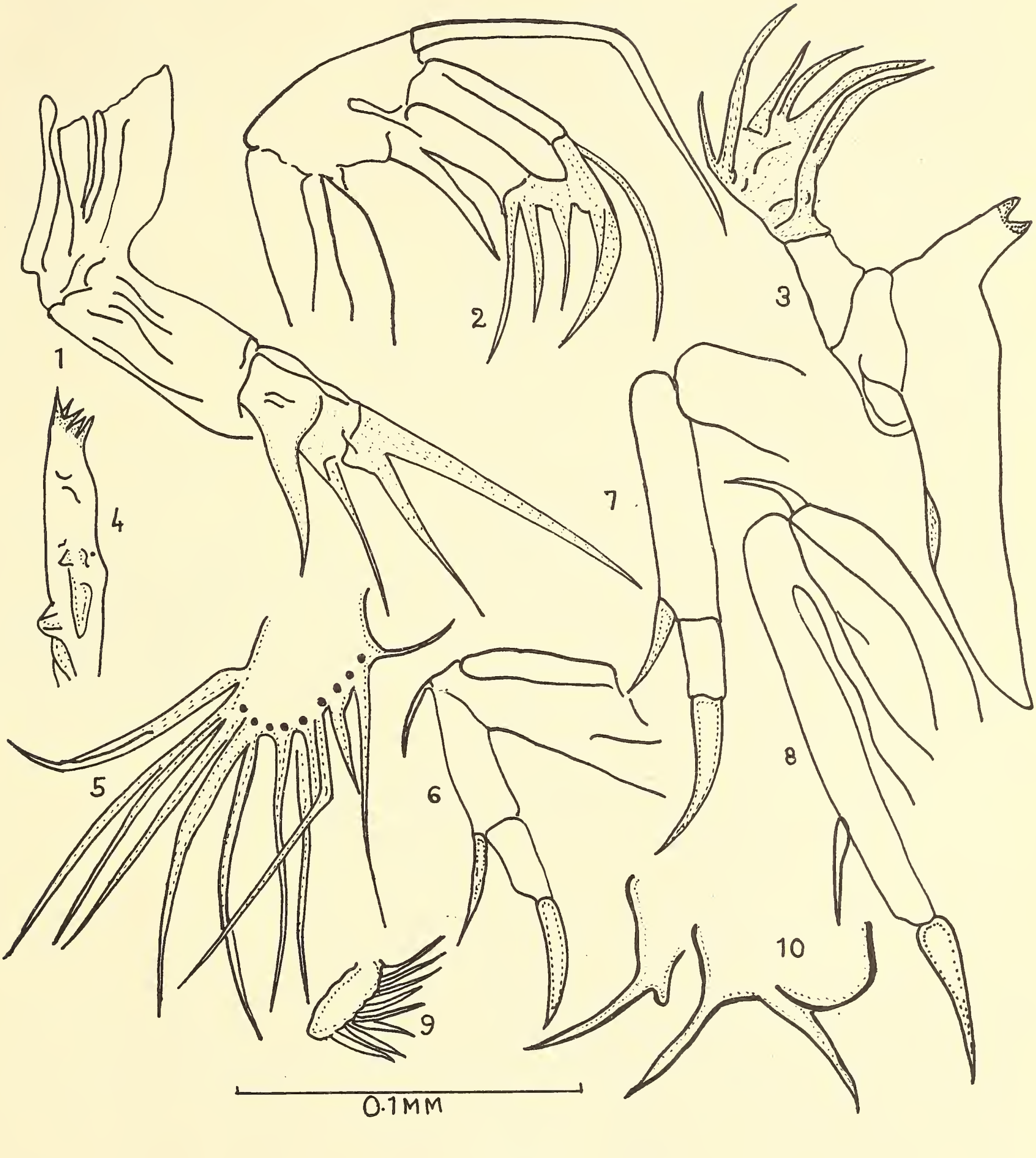


A. *Leptocythere andhraensis*—interior view of right valve; B. *Leptocythere andhraensis*—interior view of left valve; C. *Tanella estuarii*—interior view of right valve; D. *Tanella estuarii*—interior view of left valve; E. *Tanella kingmai*—interior view of right valve; F. *Tanella kingmai*—interior view of left valve.



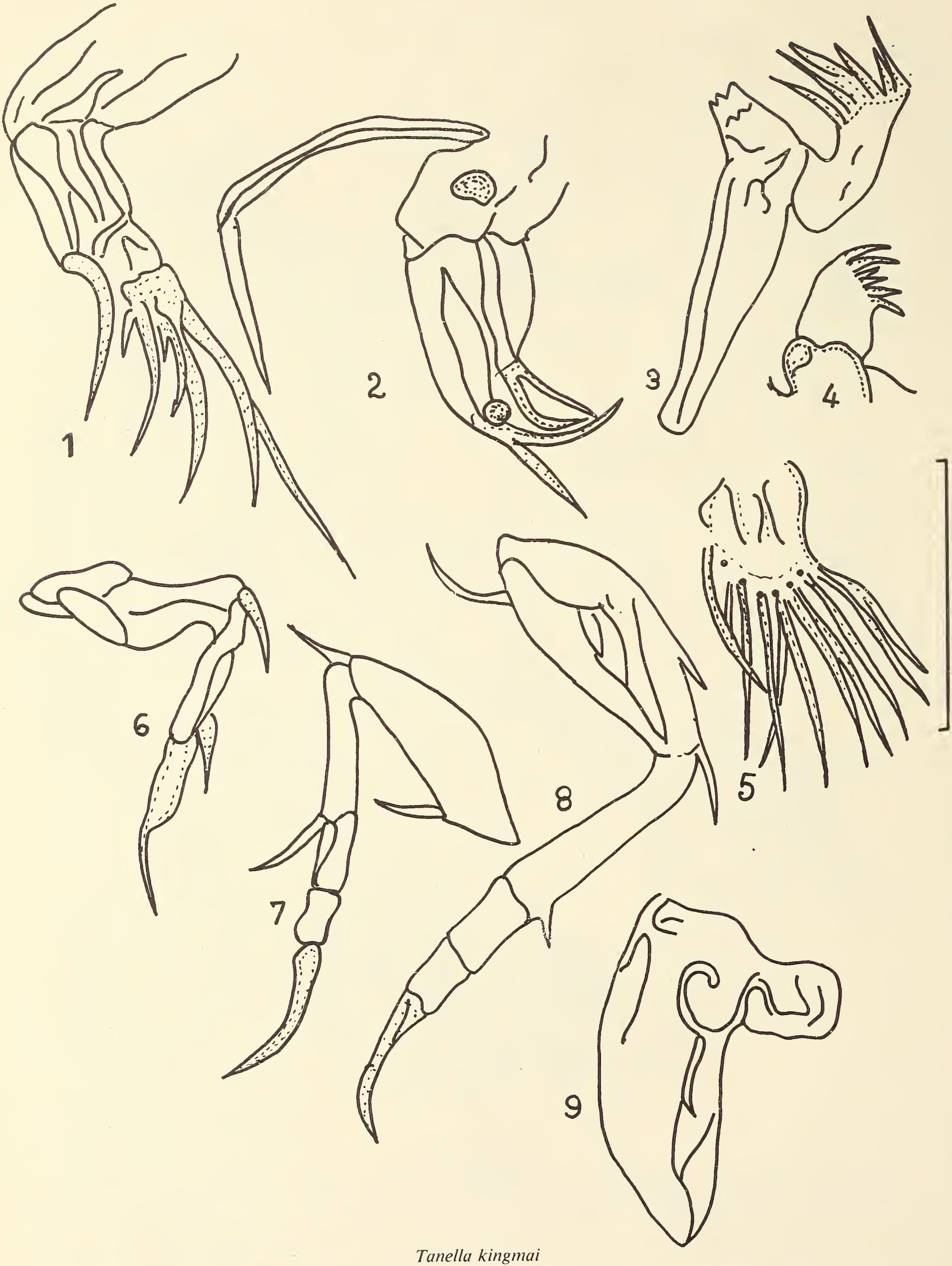
Leptocythere andheraensis

1. antennule; 2. antenna; 3. mandible; 4. mandibular palp; 5. maxilla; 6. first thoracic leg; 7. second thoracic leg; 8. third thoracic leg; 9. genital organ.



Tanella estuarii

1. antennule; 2. antenna; 3. mandible with palp; 4. maxilla; 5. vibratory plate; 6. first thoracic leg; 7. second thoracic leg; 8. third thoracic leg; 9. masticatory lobe of maxilla; 10. furcae.



Tanella kingmai

1. antennule; 2. antenna; 3. mandible with palp; 4. maxilla; 5. vibratory plate; 6. first thoracic leg; 7. second thoracic leg; 8. third thoracic leg; 9. genital organ.

the posteroventral end of the body and unsegmented.

Remarks: In the shape of carapace, marginal area and in the arrangement of muscle scars *T. estuarii* resembles *T. gracilis* and *T. vasishta.* It differs from *T. vasishta* in polyfurcate branching of marginal pore canals. *T. estuarii* differs from *T. miurensis* and *T. indica* in the shape of the carapace and surface sculptured with pits, separate and limited in number.

Type-locality: Vasishta Godaviri estuary on the east coast of India.

Type-specimens: Holotype and three paratypes are deposited in the Museum of Zoological Survey of India, Calcutta, India.

Occurrence: Bimili backwaters, Balacheruvu tidal stream and Vasishta Godavari estuary.

This species is named after the type-locality.

3b. **Tanella kingmai** sp. nov. (Plate 1, D; Plate 2, E & F; Plate 5, 1-9).

Carapace narrow and elongate; highest at anterior cardinal angle, anterior margin turning downwards and rounded. Dorsal margin straight showing concavity in the centre. Posterior and truncated above, narrowly rounded below. Anterior marginal ridges strong beginning at cardinal angle and ends in anteroventral region. Carapace sculptured by deep pits. Pits arranged in pairs in the centre at anterior end in rows. Hinge structure same as in type genus. Muscle scars 4, adductor scars in a vertical row. Furcal muscle scars not clear. Marginal pore canals same as in type genus. Sexual dimorphism clear.

Length: 0.42 mm; Height: 0.18 mm.

Antennule 4-jointed, first two podomeres as long as remaining podomeres. Penultimate podomere with single seta and ultimate podomere with 3 claw-like setae and 4 slender setae; third podomere with two claw-like setae and one slender seta. Exopodite 2-jointed not reaching ends of distal claws. Mandible with three serrate teeth placed laterally on cutting edge. Mandibular palp 3-segmented; first segment bulbous, last segment with one claw-like seta and six slender setae. In maxilla, masticatory lobe short and ends with setae, vibratory plate with 11 unfeathered rays. Thoracic legs same as that of type species.

Remarks: In the shape of the carapace, marginal area, marginal pore canals and arrangement of muscle scars *T. kingmai* resembles *T. gracilis, T. vasishta* and *T. estuarii.* It differs from *T. indica, T. miurensis* in the body shape. It differs from *T. estuarii* by the surface of the carapace being sculptured with pits, pits arranged in clusters and are innumerable. Postero-dorsal region is tilted upwards characteristically.

Type-locality: Bimili backwaters, on the east coast of India.

Type-specimens: Holotype and three paratypes are deposited in the Museum of Zoological Survey of India, Calcutta, India.

Occurrence: Bimili backwaters, Balacheruvu tidal stream and Vasishta Godavari estuary.

This species is named after Dr. J. Th. Kingma, in appreciation of his excellent work.

SUMMARY

Distinguishing characters relating to carapace and soft parts of three new ostracode species. namely *Leptocythere andhraensis, Tanella estuarii* and *T. kingmai* inhabiting the shallow backwaters of Bimili, Balacheruvu tidal stream and Vasishta Godavari estuary, on the east coast of India are described. The description of *Callistocythere* sp. aff. *C. crispata* which is recorded for the first time from the Indian waters is also given.

ACKNOWLEDGEMENTS

Thanks are due to the Head of the Department of Zoology of Andhra University for facilities, to Prof. M. Subba Rao, Geology Department for his interest and encouragement in the study and to Dr. S. V. Darvasula, Bedford Institute of Oceanography, Dartmouth, Canada for providing us with Scanning Electron Micrographs. The willing co-operation of Mr. M. Ananda Rao, Geology department in the identification of the species is thankfully acknowledged. One of us (CA) is grateful to the C.S.I.R. for financial assistance.

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FOSSIL BIRD EGG SHELL FRAGMENTS FROM KAREWAS OF KASHMIR VALLEY (J&K), INDIA: A SCANNING ELECTRON MICROSCOPE STUDY[1]

ASHOK SAHNI, V. J. GUPTA,

BHUVAN PRAKASH[2] AND B. S. KOTLIA[3]

(*With a plate and two text-figures*)

The present discovery of avian fossil egg shell fragments from the Plio-Pleistocene Karewa lake sediments is the only documented such find in India. Fossil bird egg shells, varying in thickness from 0.2 to 0.35 mm, have been discovered from two sites namely Kilar and Sombur (Karewa Group), Kashmir Valley and have been studied by scanning electron microscopy. The sediments, exposed near Kilar, constituting the Lower Karewa Formation, are about 1.8 m.y. to 1.6 m.y. in age. The ossiferous horizon at Sombur which has yielded bird egg shell fragments together with several remains of *Elephas hysudricus,* is younger than 0.73 m.y. The egg shell structure is well calcified, primatic with a smooth external surface having isolated circular pores. The mammillae are of variable size and range in diameter from 0.03 to 0.04 mm. The presence of fossil egg shells in the Karewa deposits has been attributed to birds on the basis of morphological similarities to egg shell structure of recent birds. The only group to which the Kashmir egg shells resemble are gekkonids. However, reptiles are poorly represented, the fauna being dominated by elephants, deer, horses, microtine, murid rodents, shrew-like insectivores and cyprinid fishes.

INTRODUCTION

The present paper deals with the discovery of fossil egg shell fragments from near Kilar and Sombur (Kashmir Valley), constituting the Lower and Upper Karewa respectively (Kotlia 1985). The fossil record of birds in India is rather poor as compared to the other vertebrates. Because of their light weight and delicate skeletal structure, bones are easily decomposed before the process of fossilization starts.

The egg shell of different reptiles and birds have specific microstructure (Sochava 1969, 1970 and 1971; Hirsch 1979, 1983, 1985). The hard calcareous egg shell is characteristic of birds whereas a soft parchment-like egg shell is produced by most reptiles (Hirsch 1979). On the basis of their internal structure, egg shells have been divided into two types, single layered (testudoid) and double layered (ornithoid). The double layered egg shells in turn can be subdivided into two types namely angusticanalicular and prolatocanalicular, depending upon the shape of the aeration canals running through the spongy layer. An angusticanalicular type egg shell is observed in modern birds (Sochava 1969) where aeration

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canals are narrow and have constant width. In prolatocanalicular shells, aeration canals vary greatly in transverse section. Turtles and crocodiles have testudoid type egg shell. In avian egg shells the basic units (spheroliths) are slender columns arising from the relatively narrow mammillary layer (cone layer). Spheroliths are usually wedge shaped in crocodiles and turtles (Fig. 1) (Hirsch 1985).

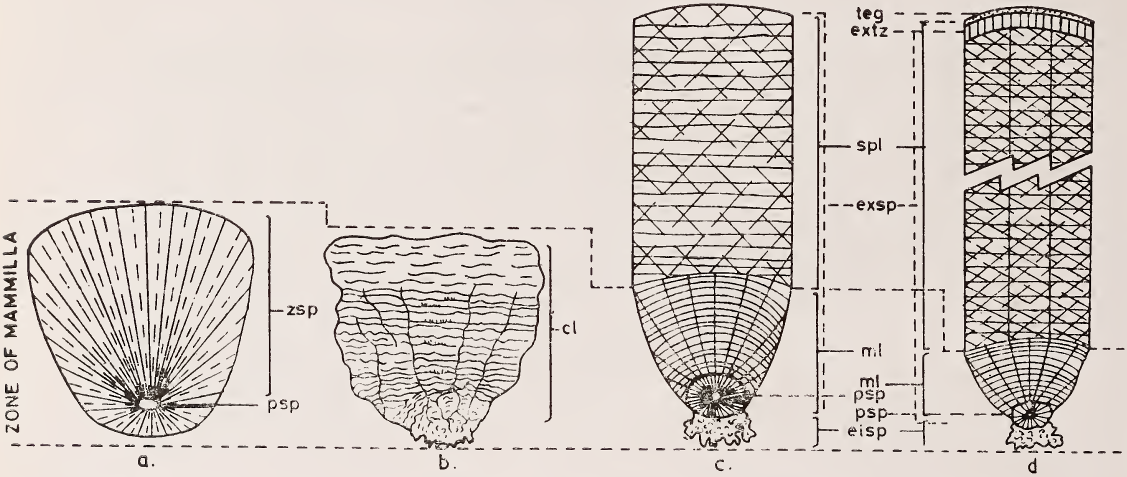


Fig. 1. Comparative structural features of egg shell in (a) Chelonia, (b) Crocodilia, (c) Dinosauria, (d) Aves (after Hirsch 1979, Erben 1970).

Abbreviations

cl — cone layer; eisp — eisosphertite; exsp — exospherite; extz — external zone; ml — mammillary layer; psp — primary spherite; spl — spongy layer; teg — tegmentum; zsp — zone of spherite.

Dinosaurian egg shells are closest to those of birds in structure and have similar corresponding basic units to those found in bird egg shells (Fig. 1) (Sochava 1970). Dinosaur egg shells, about 75 to 65 million years in age have recently been described from Jabalpur (Sahni and Gupta 1982). Nagpur and other regionally adjacent localities (Sahni *et al.* 1984, Jain and Sahni 1985).

Fossil avifauna from the Indian subcontinent is known from the Siwalik Group of rocks (Lydekker 1984, Sahni, in press). The fossil birds so far recovered from the Siwaliks are mostly aquatic except for the remains of some large terrestrial flightless birds. The remains of aquatic birds (herons, pelicans) are best preserved in sediments in sites around their natural habitat for example lakes, rivers and along coastal areas. Hence, this group is relatively better represented as fossils. Though very little is known about the fossil record of birds, earlier descriptions of Siwalik birds are known from the notes of Capt. Hugh Falconer and Gen. Sir S. W. Baker. Later, the collection of Falconer and Cautley were published by Lydekker in 1879. Lydekker (1884) reported a number of birds from the Siwalik Group rocks. His scheme of classification was somewhat incomplete again due to the lack of most of the diagnostic characters and was limited to fragmentary limb bones and vertebrae. Siwalik birds were reviewed recently by Sahni (in press). The main birds from the Siwaliks are: *Pelicanus cautleyi, P. sivalensis, Phalacrocorax, Leptoptilus, Argola, Mergus, Struthio asiaticus* and *Dromaeus* (?) *sivalensis.*

Pelicanus cautleyi and *P. sivalensis* are recognized by the distal extremity of the ulna which is smaller than in the existing Indian and African *P. mitratus.* Later, De Terra and Paterson (1939) carried out considerable and comprehensive field work in the Karewas and reported the remains of birds along with the remains of *Elephas hysudricus* and a number of bones of artiodactyls mammals from 'Sombur Bone Bed'. More recently, Tripathi and Chandra (1962), on the basis of skeletal elements also reported birds (but did not illustrate or describe these) from the Lower Karewa deposits, exposed at Nichahoma and Tsrar Sherif. The remains of the struthious birds are relatively more common because of the more robust nature of their bones (Lydekker 1884). Ostrich egg shells at some archaeological sites in western India are also known (H. D. Sankalia, pers. comm.).

LOCALITY AND STRATIGRAPHIC POSITION

The Valley of Kashmir is symmetrically oriented about the northwest syntaxis and is an intermontane basin developed within the southern Himalayan Schuppenstruktur. It has accumulated about 1225 m of Plio-Pleistocene synorogenic sediments (deltaic, lacustrine, fluvio-glacial). These sediments lie unconformably over the Panjal Trap and Triassic Limestone. On the basis of different lithologies, Karewas have been divided into three structural units i.e., Lower and upper Karewa Formations and Loess deposits (Bhatt 1979, Agrawal *et al.* 1979). The developmental history of the intermontane basin of Kashmir, based on geological and palaeomagnetic studies have shown that Karewa sedimentation had been initiated by about 4.0 m.y. ago (Burbank and Johnson 1982, Kusumgar *et al.* 1985a, b). Since then, lacustrine and glacio-fluvial sediments dominating the Karewa sequence have preserved a large number of megavertebrates (Badam 1979, Sahni 1982, Kotlia *et al.* 1982. Kotlia 1985) as well as microvertebrate and micromammals (Sahni and Kotlia 1983, 1985; Kotlia 1985).

Fossil bird egg shell fragments have been recovered from two localities, Kilar and Sombur, constituting the Lower Karewas and Upper Karewa respectively. Kilar section (33°48′03″N, 74°75′53″E), the lateral extension of the Romushi Karewa sediments, is exposed along Birnai Nala between Kilar and Lasidaban villages (Fig. 2A, B), 60 km SW of Srinagar. The section is considered to be lithologically equivalent to part of the Romushi section exposed below Aglar Conglomerate and is ascribed to the same formation as the conglomerate horizon exposed at the top of the Kilar section which has been physically traced to Aglar village where it constitutes a well organised conglomeratic bed (Kotlia 1985): Kilar section comprises a compact and bluish mudstone sequence interlayered by fine grained sandstone layers showing wave built structures. The bluish lenticular sand bodies are associated with finely laminated yellowish rhythmite layers showing wave ripples. The sediments, specially in the middle part of the section are rather disturbed and not continuously exposed. The upper part of Kilar section is a mudstone-sandstone succession dominated by compact and bluish mudstone with thin and thick sandstone alternations. The mudstone dominant succession contains abundant gastropod shells at the base otherwise it shows faint laminations. Detailed lithostratigraphy of

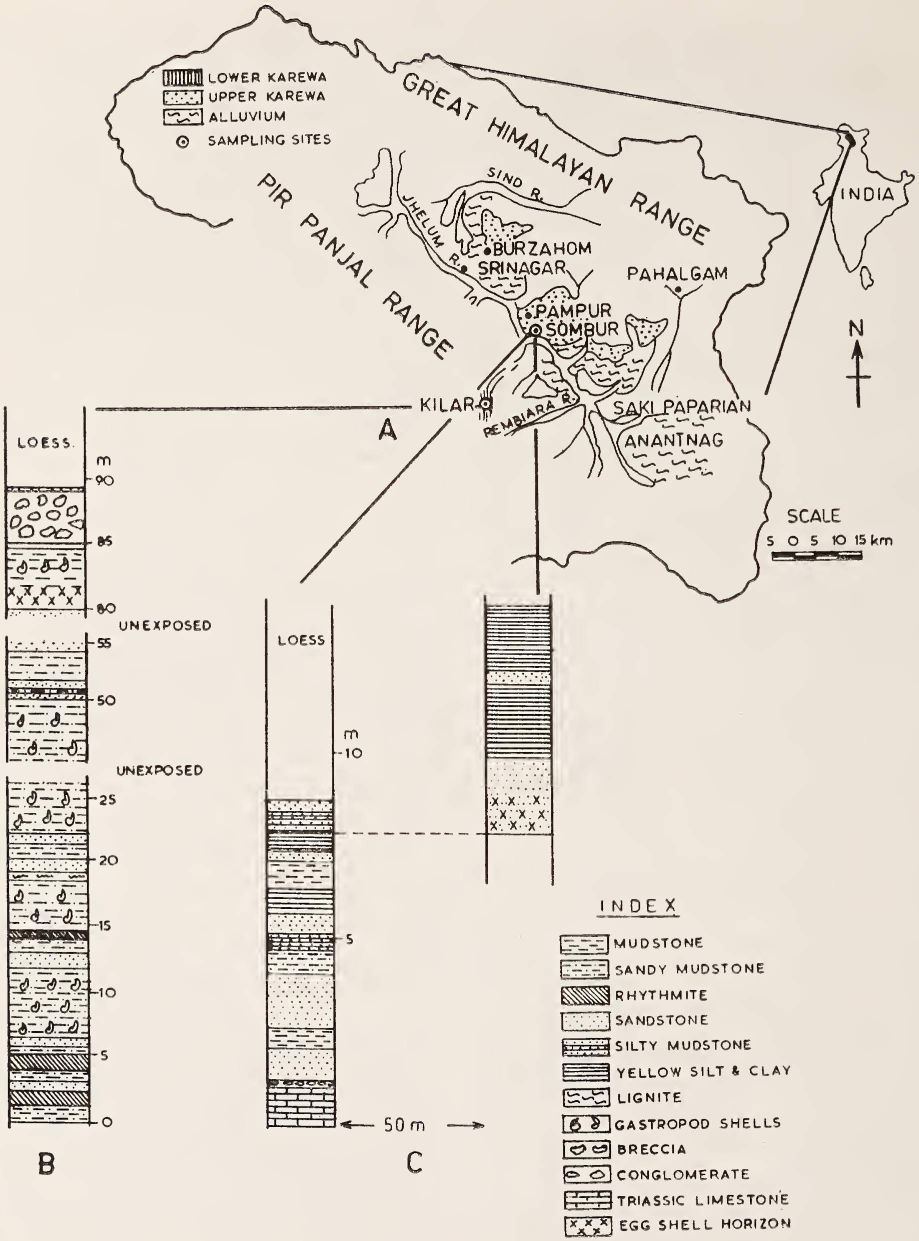

LOWER KAREWA
UPPER KAREWA
ALLUVIUM
SAMPLING SITES
GREAT HIMALAYAN RANGE
PIR PANJAL RANGE
SIND R.
JHELUM R.
BURZAHOM
SRINAGAR
PAHALGAM
PAMPUR
SOMBUR
KILAR
REMBIARA R.
SAKI PAPARIAN
ANANTNAG
INDIA
N
SCALE
5 0 5 10 15 km
A
LOESS
m
90
85
80
UNEXPOSED
55
50
UNEXPOSED
25
20
15
10
5
0
B
LOESS
m
10
5
50 m
C
INDEX
MUDSTONE
SANDY MUDSTONE
RHYTHMITE
SANDSTONE
SILTY MUDSTONE
YELLOW SILT & CLAY
LIGNITE
GASTROPOD SHELLS
BRECCIA
CONGLOMERATE
TRIASSIC LIMESTONE
EGG SHELL HORIZON

Fig. 2. A. A part of the geological map of Kashmir Valley showing sampling localities (modified after Bhatt 1976); B. Lower Karewa section exposed at Kilar showing fossil bird egg shell horizon (after Kotlia 1985); C. Upper Karewa section exposed at Sombur showing egg shell horizon (after Kotlia 1985).

Kilar section has been studied by Kotlia (1985).

The egg shell fragments have been discovered from the ossiferous horizon in the topmost part of the section, just below the conglomerate succession. The bluish coloured lenticular sand bodies and the 1-2 cm thick silty mudstone layers have also yielded the post-cranial remains of *Equus sivalensis* associated with microtine and murid rodents (Kotlia 1985).

The fossil bird egg shell fragments are also recovered from Sombur (33°57′02″N; 74°57′10″E), an Upper Karewa locality, 18 km NE of Srinagar. This ossiferous horizon which forms a part of the Upper Karewa Formation lies stratigraphically 8 m above the "Sombur Bone Bed" (Fig. 2C). Sombur sediments, overlying the Triassic Limestone, are composed of laminated silt and clay, associated with fine to medium sand bodies. The Triassic Limestone is poorly exposed on which rests a 7-9 cm thick limestone breccia which is followed upward by a thin conglomeratic horizon consisting of Triassic Limestone, Panjal Trap pebbles and boulders, this conglomeratic horizon in turn is followed by fine to medium grained sandstone associated with layers of silt and clay with minor pebbly horizon at the base. Being rich in vertebrates, it was named "Sombur Bone Bed" (De Terra and Paterson 1939). Above this conglomeratic horizon lies about 50 cm thick fine grained lenticular sand body intercalated with yellowish silt and clay layers. This sandy layer is overlain by a yellowish silt and clay bed. Above this sequence, loessic deposits are located showing weakly developed palaeosol sands.

The egg shell yielding horizon, exposed about 50 m away from the main section (Fig. 2C) consists of fine grained greenish sandstone, interlayered with yellowish clays beds. The ossiferous horizon is overlain by a thick light yellowish silt layer in which a few lenses of clay and fine sand are seen.

It may be pointed out that Sombur sediments are considered by most workers, e.g. De Terra and Paterson (1939) and Bhatt (1982) to be a part of the Lower Karewa Formation. Following Wadia (1951), Agrawal *et al.* (1979), Singh (1982) and Kotlia (1985), we opine that the nature and sequential build up of Sombur sediments is of Upper Karewa age. The topmost member of Sombur section is a loess bed, the uppermost Karewa structural unit, capping the Karewa sediments everywhere in the Kashmir Valley. The loessic deposits range in thickness from 15 to 25 m on the Himalayan flanks and Pir Panjal flanks respectively. SEM studies of loess and palaeosol (Pant *et al.* 1978) indicate that the palaeosol bands represent buried weathered soil erosion. The lowermost and the uppermost palaeosols, exposed at Burzahom, on the Himalayan flank are radiocarbon dated to >31000 and 18000 year B. P. respectively (Agrawal *et al.* 1979).

AGE OF OSSIFEROUS HORIZONS

Based on the magnetic measurements (Kusumgar *et al.* 1985a, b; Kotlia 1985), Kilar sediments, yielding the egg shell fragments fall well within the Olduvai Event (1.8 m.y. to 1.6 m.y.), whereas Sombur sediments fall within the Brunhes magnetic epoch, hence are younger than 0.73 m.y.

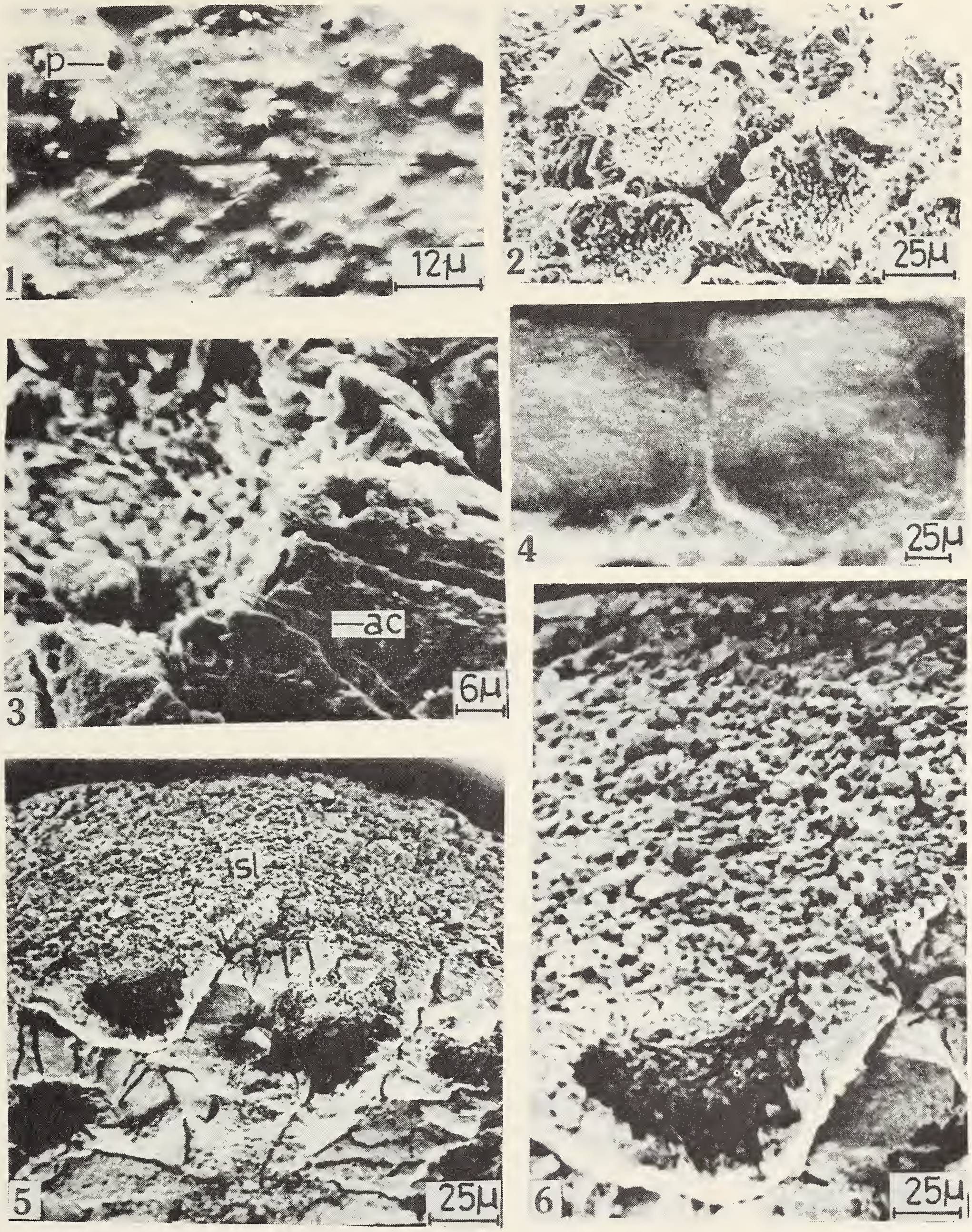
SYSTEMATICS

Scanning electron microscopy has confirmed the structure of these egg shells. Because of the isolated, assorted nature of the egg shell fragments, it is not possible to definitely relate the egg shells to any particular bird genus. There appear at least two different types of egg shells judging from the different thickness of the shells. Their ultrastructure, however, is fairly similar and presently no further light can be thrown on the taxonomic affinities of these two egg shell types. It is speculated, given the palaeoenvironmental conditions, that the eggs may have belonged to aquatic birds. Such birds have been reported earlier by Lydekker (1884). The other group of vertebrates which have a rigid calcareous egg shells and which are found in Karewa sediments (albeit rarely) are gekkonid lizards. Little is known about the ultrastructure of gekkonid shells and so presently the shell fragments are being referred to birds. At present, there is no fossil record in the Kashmir Karewa of turtles, crocodiles and snakes some of which have rigid calcareous shells.

The shell fragments are represented by about fifteen specimens less than a square mm in size. Nearly all the specimens exhibit a smooth surface exposed above the spheroidal surface of the shell (Plate 1, Figs. 1, 5). The thickness of shell varies from 0.2 to 0.35 mm. The shells have simple isolated spherical nodes sometimes showing elongation and extended nodes which coalesce together to form ridges. Fig. 1 (Plate 1) displays simple as well as spherical nodes rising from the delicately sculptured surface having sparse and indistinct pore openings. On the smooth external surface, the presence of minute pores can be observed (Plate 1, Fig. 1). External pores are not depressed into the surface but rather the edge of each orifice is nearly flat. The openings are generally circular but may be subcircular with the deviations being arcuate expansions of a circle rather than subcircular restrictions. Study of the transverse sections of egg shells under light microscope shows the retention of the spherolith structure. Because of the spongy nature of the prismatic layer, spheroliths are not clear (Plate 1, Fig. 4) but boundaries of individual units are easily discernible. Dughi and Sirugue (1976) also stressed the presence of the spongy nature of the prismatic layer in avian egg shell which is supposedly absent in reptilian egg shells.

The internal surface shows well developed mammillary knobs with a coarse and irregular appearance of the mammillary layer. The mammillary knobs have well developed and radial spicular calcite/aragonite. The mammillae are of variable size and range in diameter from 0.03 to 0.04 mm. Some specimens (Plate 1, Figs. 2, 3) show distinct resorption craters. Resorption craters in these egg shells indicate that the embryo developed absorbing and leaching out the calcium minerals of the outer shell. The mammillae, normally appear as subrounded cones and are loosely associated, allowing for an inter-mammillary ventilation system. In longitudinal sectional view, the individual spheroliths are not very distinct (Plate 1, Figs. 5, 6). The mammillary layer is restricted somewhat internally. The greater part consists of the spongy or prismatic layer. The external layer is not well defined. Under electron microscope, spheroliths are clear and aeration canals extend from inner or papillary layer to the external surface (Plate 1, Figs. 5, 6). Aeration canals have been described by Erben (1970) for *Struthio* and *Rhea* bird egg shells. In the specimens (Plate 1, Figs. 2, 3) aeration canals are very prominent part of the structure. They seem to radiate out from the mammillae extending towards the external surface. They are not traceable within spongy or prismatic layer (Plate 1, Figs. 4, 5) though their extension can be observed on the shell surface. These aeration canals transmit oxygen required for breathing of the embryo (Sochava 1970).

All specimens examined by scanning electron microscopy, show all the structures of an



FOSSIL BIRD EGG SHELL

1. External surface view showing pores; 2. Mamillary surface showing resorption craters with aeration canals; 3. Enlarged view of single mammillae showing aeration canals having constant width; 4. Longitudinal section showing two distinct spheroliths; 5. Longitudinal section showing mammillae and spongy layer; 6. Enlarged view of single mammillae showing mammillae and spongy layer.

Abbreviations

ac, aeration canal; p, pores; sl, spongy layer.

avian egg as also indicated by Thaler (1965) in his identification of the fundamental difference between eggs of birds and dinosaurs. Thaler (1965) separated them on the basis of the microcrystalline structure of the shell and accepted that in the bird eggs, the customary definition of a mammillary spherolithic zone is distinct from an upper arched or spongy layer. In his comprehensive review of egg shell structure of reptiles and birds, Erben (1970) studied the ultrastructure of various birds. He described in detail the various component units of avian egg shell structure and pointed out that while the avian structural pattern was similar to that of other reptiles, it could be easily differentiated from that of other reptiles. Recently, Sahni *et al.* (1984) have described some thin egg shell fragments from the Cretaceous-Palaeocene beds of peninsular India and ascribed them to of uncertain relationship, possibly related to dinosaurian, avian or lacertilian affinities. The Kashmir egg shells have a comparable shell thickness and are found associated with a similar biotic component (fishes, charophytes, ostracods, molluscs) indicating a similar depositional environment. However, in the absence of comparative material, it is presently not possible to precisely document the affinities of thin egg shells.

PALAEOECOLOGY

A preliminary study of the faunal assemblage from Kilar reveals that the material was transported from both long and the short distances and was probably secondarily concentrated in the Karewa basin (Kotlia 1985). Fossil vertebrates belonging to the upland and lacustrine communities are found in the Kilar sediments. The presence of microtine rodents in these sediments indicate the advent of the colder climatic conditions. Torrential river fishes, i.e. *Schizothorax* and *Oreinus* together with microtine rodents, constituting the major part of Kilar fauna (Sahni and Kotlia 1983) are still unknown from the contemporaneous Siwaliks of India. The reason for disparity in type of fishes and rodents found both in the Karewas and the Siwaliks could be due to the lower temperatures prevailing in the Plio/ Pleistocene of the Kashmir Valley in comparison to those of Pinjor basin of the Siwaliks.

We opine that the lacustrine and fluvial conditions persisted during the deposition of the Sombur sediments which have yielded scattered micromammalian fauna. In the lower part of the section, the lacustrine environment persisted as is indicated by current bedded and lenticular gritty sand bodies. The absence of lignite layers in Sombur section may indicate the absence of swampy environment.

The presence of bird egg shells in Kilar and Sombur sections indicate that birds formed a small but important part of the Karewa lake community through a wide temporal span. When one considers the fact that most of the Karewa ecosystem has been stable and has not changed significantly from the present ecosystem, it is reasonable to assume that the birds, like their modern day counterparts were marsh or lake dwellers and probably were nourished by the abundant fish fauna.

ACKNOWLEDGEMENTS

We are grateful to Prof. S. B. Bhatia, Chairman, Centre of Advanced Study in Geology, Panjab University, Chandigarh for the help rendered during this work. We wish to express our thanks to Prof. D. P. Agrawal, Project Leader, Kashmir Palaeoclimate Project, for logistic help and fruitful discussions. The financial assistance from CAS in Geology to Bhuvan Prakash is gratefully acknowledged.

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NEW DESCRIPTIONS

A NEW SPECIES OF *COPRIS* MULLER (COLEOPTERA: SCARABAEIDAE) FROM SOUTH INDIA[1]

B. D. Gill[2]

(*With a plate*)

Copris keralensis sp. nov. is described from the rainforests of Kerala State. It appears closely related to species in the subgenus *Paracopris* Balth. Both sexes are figured.

In the process of gathering data on the foraging behavior of Scarabaeinae, a series of an unsual species of *Copris* was collected in the rainforests of the Western Ghats. Comparison with material in the collections in Paris and subsequent search of the literature has confirmed that it is indeed a new species and is described below. The sexual dimorphism exhibited by this species is unusual for the subgenus *Paracopris* Balthasar (1939) to which it evidently belongs.

Copris keralensis sp. nov.

(Plate I-Figs. 1, 2, 3, 4)

Holotype. Male length 12.3 mm, greatest width 6.9 mm. Body and legs chocolate-brown; antennae reddish-brown. Head and ventral surface strongly shining, pronotum less shining; elytra and pygidium opaque. Clypeus (Fig. 1) broadly bidentate, margin reflexed; surface smooth anteriorly, punctate basally. Frons with a long conical horn arising medially in front of eyes, slightly inclined posteriorly. Pronotum lacking median groove or line; very densely punctate, appearing rugose; punctures with minute yellowish setae. Anterior emargination of pronotum with broad marginal membrane; margin with a median pair of sharp anteriorly directed teeth. Elytra lightly striate, striae with coarse shallow punctures; intervals flat, finely sparsely punctate, punctures with short yellowish setae. Pygidium densely punctate, punctures minutely setose. Metasternum finely punctate medially, coarsely punctate anteriorly and laterally. Ventral surface of femora closely punctured. Front tibia with four teeth; apex of tibial spur bluntly rounded. Genitalia as in figs. 3 and 4.

Allotype. Female, length 12.2 mm, greatest width 6.8 mm. Differing from holotype in the following characters: frons (Fig. 2) with a slightly elevated median tubercle arising just in front of the eyes; anterior margin of pronotum obtusely angulate at midline, lacking teeth; front tibia with apical spur acutely rounded.

Type Material. Holotype, male, India, Kerala, 60 km E Alwaye, 1 VIII 1984, B. Gill, 300 m. Allotype, female, same data as holotype. Paratypes, 4 males, 11 females same data as holotype; 2 males, 8 females, India, Kerala, 66 km E Alwaye, 1 VIII 1984, B. Gill, 500 m. Holotype and allotype deposited in the National Museum of Natural History (Ottawa, Canada). Paratypes in the Zoologi-

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[1] Accepted October 1985.

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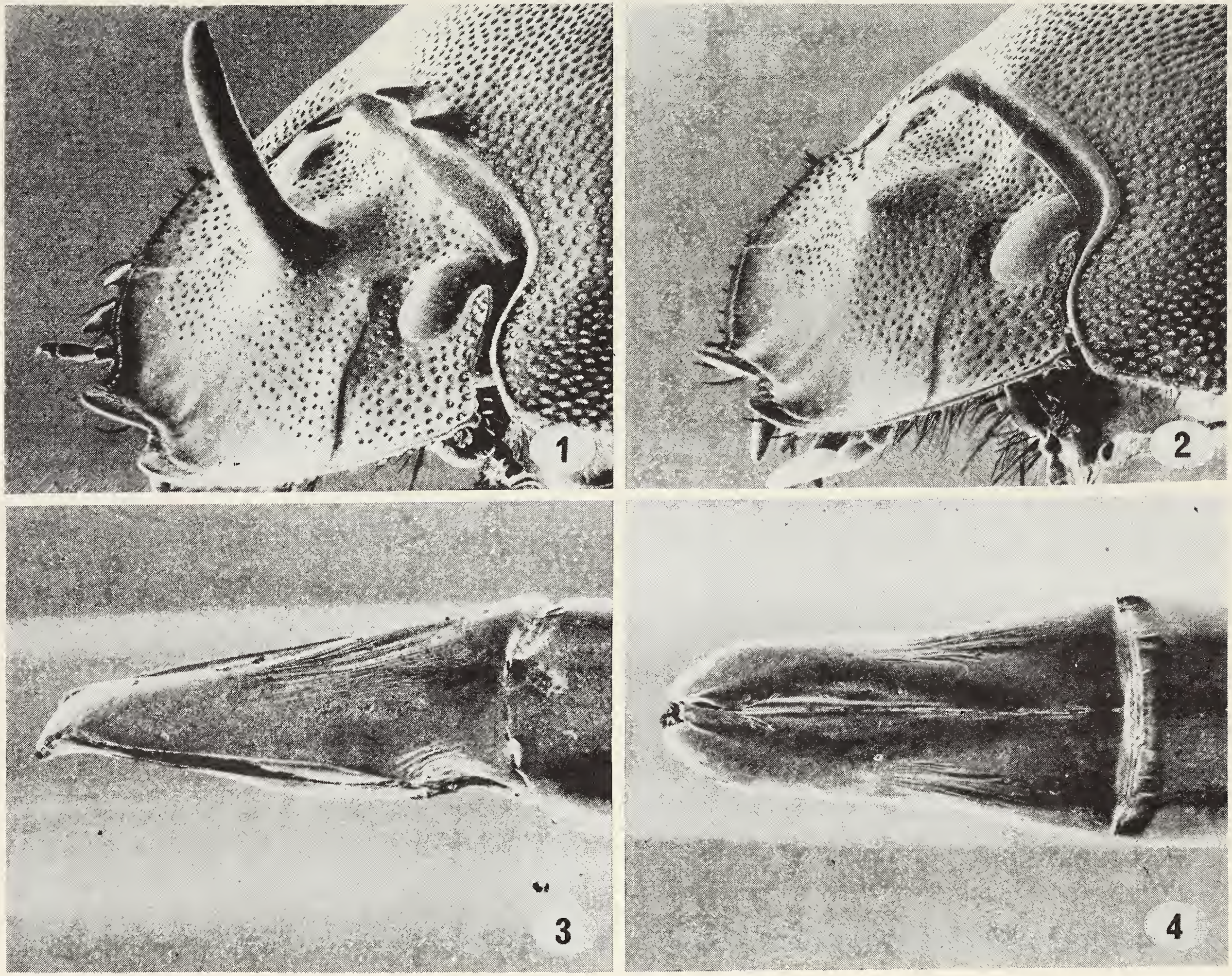

Figs. 1-4. *Copris keralensis* sp. nov.

1. Holotype, head and pronotum; 2. Allotype, head and pronotum; 3. Holotype, lateral view of genitalia; 4. Holotype, drosal view of genitalia.

cal Survey of India (Calcutta), Museum National d'Histoire Naturelle (Paris), H. & A. Howden collection (Ottawa) and B. Gill collection (Ottawa).

Remarks. The 25 paratypes range from 10.5 to 13.0 mm in length. With the exception of a few teneral individuals that are reddish-brown, the paratypes do not vary noticeably from the holotype. The evenly convex pronotum, punctate metasternum and smooth clypeus will cause the new species to key out to *C. furciceps* Felsche in Arrow's FAUNA OF BRITISH INDIA (1931). It can be distinguished from that species by the broadly bidentate clypeal margin and the presence of a single horn or tubercle upon the frons. The presence of two sharp teeth on the anterior margin of the pronotum in the males is also very distinctive of the new species.

Copris keralensis appears to be closely related to a number of species placed in the subgenus *Paracopris* by Balthasar (1963). It shares with them nearly opaque coloration, slender legs and a strongly punctate and flattened body form. However the sexually dimorphic pronotum of this species certainly falls outside of the subgeneric limits established by Balthasar (1963, p. 329) "der Halsschild ist in beiden Gruppen vollkommen einfach..." A re-evaluation of the characters used to partition the genus *Copris* (s. lat.) may therefore be warranted (Paulian 1945).

All specimens were collected in pitfall traps placed in the forest and baited with 2 ml of human dung. Traps were similar in design to those used by Peck and Howden (1984).

ACKNOWLEDGEMENTS

I am most grateful to G. M. Sirur and family for their generous hospitality and assistance during the field work in India. Dr. H. F. Howden very kindly provided financial support and guidance for this research. Dr. C. Scholtz assisted with the German translations and Mr. L. E. C. Ling took the scanning micrographs.

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JOURNAL, BOMBAY NATURAL HIST. SOCIETY, Vol. 83

NEW SPECIES OF SCORPION OF THE GENUS *LYCHAS* (BUTHIDAE: SCORPIONIDA) FROM NASIK DISTRICT, MAHARASHTRA, INDIA[1]

D. B. BASTAWADE[2]

(*With thirteen text-figures*)

INTRODUCTION

Eleven species of the genus *Lychas* C. Koch, are known from Indian sub-continent. Among these six species under three sub-genera have been described from the southern part of India (Tikader & Bastawade 1983). I continued the study of Indian Scorpions and recently collected a good number of scorpion specimens from Western portion of Nasik district during my Western Ghat Survey (1984). The genus *Lychas* is known only by *Lychas* (*Alterotrichus*) *rugosus* (Pocock) from Nasik District. The present communication describes a new species from Kharpadi village, Harsul, Peinth Taluk of Nasik district.

Lychas (Alterotrichus) kharpadi sp. nov.

(Figs. 1-13)

General: Yellow scorpion of small to medium body size. Carapace and mesosoma sparsely and weakly granular and with few scattered dark patches. Male smaller and more slender than female. Metasoma reddish brown on posterior segments and telson. Pedipalps delicate. Pectines well developed.

Measurements: ♂ — Total length 38.75 mm. Carapace 4.50 mm long, mesosoma 11.50 mm long, metasoma 22.75 mm long.

♀ — Total length 45.25 mm. Carapace 5.00 mm long, mesosoma 15.00 mm. long, metasoma 25.25 mm long.

Carapace: Entire surface weakly and sparsely granular. A pair of median eyes situated anteriorly in the ratio 1: 2.25 as in fig. 1. Five pairs of lateral eyes present on anteriolateral portion with smooth lateral ocular tubercles of which two anterior pairs directed anterio-laterally, third pair posterio-laterally and last two pairs dorso-posteriorly and posteriorly respctively. Interocular portion black and more granular on anterior. Carinae absent. Anterior margin invaginated slightly and smooth. Lateral margins finely crenulated. Posterior margin smooth. *Chelicerae* smooth on basal segment with typical Buthid dentition except only one tooth on ventral surface of immovable finger. *Pedipalps*: Delicate, carinated and confusicated on femur and patella. Femur as long as carapace but shorter than patella, all carinae crenulated. Patella carinated and anterior or inner carinae evenly crenulated. Manus smooth, without carinae and length of under hands less than half the length of femur. Fingers as long as patella, smooth. Dentition on fingers over-lapping, with two unpaired teeth on proximal portion of movable fingers as in fig. 2 and a strong apical tooth. Trichobothrial pattern on pedipalp of typical *Alterotrichus* types but differs from known species of the sub-genus as in figs. 6-13. *Legs*: delicate, weak, finely granular and carinated on femur and patella. Tibia smooth, with very short and inconspicuous tibial spur on III & IV pairs. Tarsomere I almost as long as tibia but slender, smooth and clothed with

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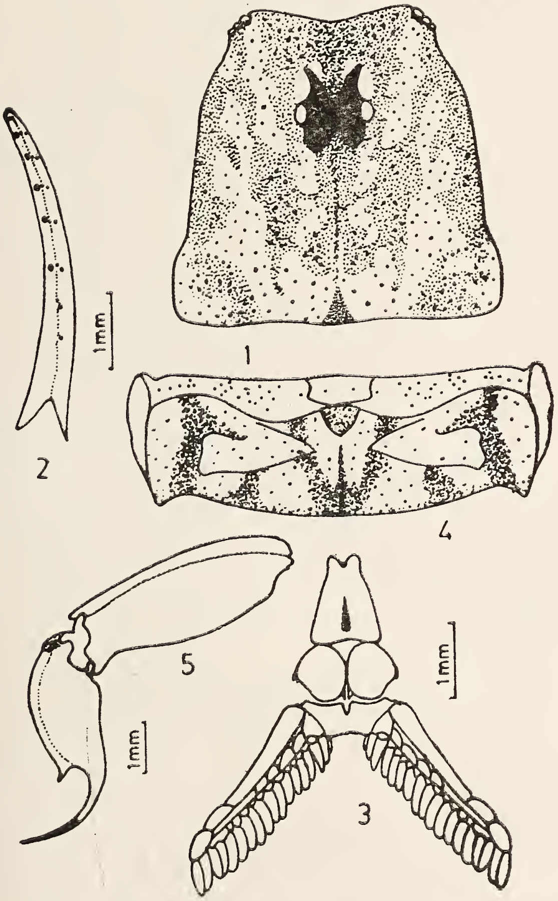
[1] Accepted March 1985.

[2] Zoological Survey of India, Western Regional Station, Pune 411 016.

bristles on ventral portion. Tarsomere II delicate, thin, smooth, covered thickly with paired bristles on ventral portion. A pair of claws strong. *Pectines*: A pair of pectines well developed and more than four times as long as wide, middle lamillae divided into 8-9 small pieces. Fulcra distinct. Lamillae and fulcra covered with setae. Pectinal teeth strong in male and 17/17 in number and 18/18 in female. Basal piece smooth, not much sclerotized and invaginated on anterior margin as in fig. 3. Genital operculum wider than long, a pair of sclerites exposed posteriorly in male through which male papillae visible, while completely fused in female. Cephalothoracic sternum triangular.

Mesosoma: All tergites sparsely granular. Tergites I-VI monocarinated, with three dark and four yellow spots on posterior portion as in fig. 4. Lateral margins crenulated, posterior smooth. Pretergal portion finely granular. Tergite VII more granular and with four crenulated carinae. Lateral and posterior margins granular. Sternites III-VI smooth, lateral and posterior-margins also smooth, each sternite with a pair of book lungs. Last sternite



Figs. 1-5. *Lychas* (*Alterotrichus*) *kharpadi* sp. nov. 1. Dorsal aspects of carapace; 2. Dorsal view of movable finger of pedipalp; 3. Ventral aspects of cephalothoracic sternum, genital operculum and pectines; 4. Dorsal aspects of tergite III; 5. Lateral aspects of Metasomal segment V & Telson.

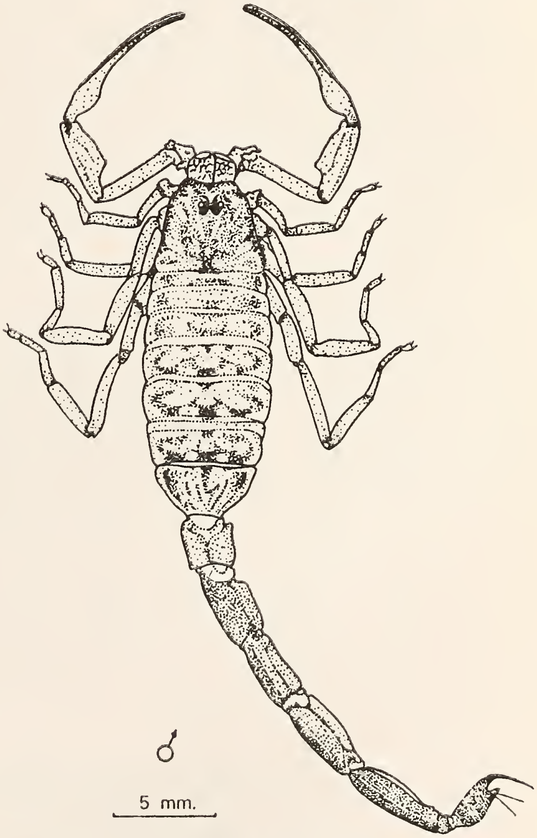
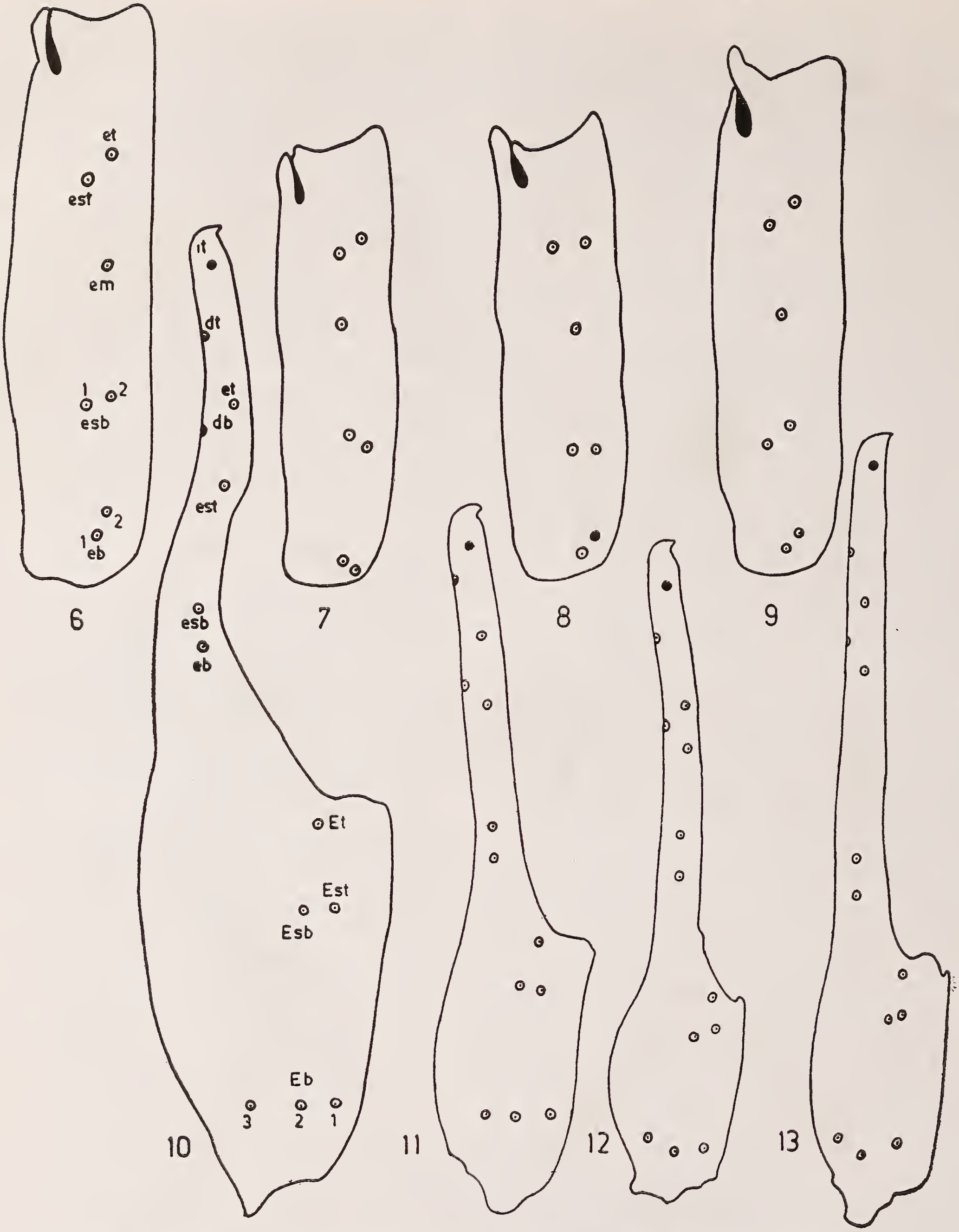


Fig. 1A. Dorsal view of Holotype ♂.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Figs. 6-9. Showing trichobothrial patterns on exterior surface of patella for 6. *mucronatus*; 7. *rugosus*; 8. *hendersoni*; 9. *kharpadi* sp. nov.

Figs. 10-13. Showing trichobothrial patterns on exterior surface of Manus and immovable finger of Pedipalp 10. *mucronatus*; 11. *rugosus*; 12. *hendersoni*; 13. *kharpadi* sp. nov.

granular and carinated. Carinae weakly crenulated and granules obsolete. Lateral margins crenulated. Posterior margin smooth. Presternal portion short and smooth.

Metasoma: Cauda slightly more than five times as long as carapace. Basal segment longer than wide. All segments carinated. Segments I and II with all eight carinae, all carinae crenulated. Segments III & IV with six carinae, all carinae crenulated and lateral carinae developed only on half of anterior portion of segment III. Dorsal carinae on segments I-IV weakly tuberculate posteriorly. Intercarinal portion weakly and much sparsely granular. Anterior and posterior margins of each segment smooth. Segment V almost as long as carapace, only inferior lateral and single inferior median carinae poorly granular and weakly crenulated. Intercarinal space poorly granular. Anal rim of this segment smooth. Telson slightly shorter than segment V. Vesicle as long as segment II, weakly granular, ventral median crest ending posteriorly into a subaculear spine, provided with a pair of minute teeth on inner margin. Aculeus long, as long as vesicle, sharp, not much curved and dark on distal portion as in fig. 5.

Etymology: The specific name refers to the locality and has been used as a noun in apposition.

Type-specimens: *Holotype*: 1♂ in spirit. *Allotype*: 1 ♀ in spirit, will be shortly deposited in the National Collection, Zoological Survey of India, Calcutta.

Type-locality: Near Kharpadi village, Harsul, Taluk Peinth, Nasik district, Maharashtra, India. 4.ii.1984. Coll. D. B. Bastawade.

Distribution: Known only from type locality.

Habit and Habitat: This species is arboreal in habit and lives under the bark of trees. The specimens were collected from a height of 10′ to 11′ above the ground.

Discussion: This species closely resembles *Lychas* (*Alterotrichus*) *hendersoni* Pocock in its colour patterns and in having the same number of pectinal teeth but it differs as follows: i) Movable finger of pedipalp has two unpaired proximal teeth in outer row. (ii) Inter relations between the trichobothria *et*, *est* and em_1 & em_2 on patella of pedipalp totally different from that of known species (Figs. 7-10). (iii) Inter relations between the trichobothria *dt*, *db* to *et est* on immovable finger of pedipalp are also different from that of known species (Figs. 11-13).

ACKNOWLEDGEMENTS

I thank Dr. B. K. Tikader, Director, Zoological Survey of India, Calcutta and Officer-in-Charge, Zoological Survey of India, Western Regional Station, Pune for providing facilities to carry out this work. My thanks are also due to Mr. P. W. Garde for preparing the final diagrams for this paper.

REFERENCE

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DESCRIPTION OF TWO NEW SPECIES OF CLADOCERA OF FAMILY DAPHNIIDAE FROM MADHYA PRADESH, INDIA[1]

Pramod D. Rane[2]

(*With two text-figures*)

Daphniopsis sumanae sp. nov. and *Daphnia sarojae* sp. nov., two cladocerans collected from Jabalpur and Mandla districts of Madhya Pradesh are described and illustrated. The new species are compared with their closely allied species. Types are deposited in National Collection of Zoological Survey of India, Calcutta, and the registration numbers are given in text.

Daphniopsis sumanae sp. nov.

(Fig. 1)

FEMALE

Head relatively large, never producing any helmets, length of the head is slightly more than 1/3 of its height and $\frac{1}{4}$ of the valve length. Anterior lateral margin of the head above the eyes almost straight which gives appearance like a triangular head. Optical vesicle placed more dorsally and anteriorly from the longest point of head. Ocellus small, triangular. Rostrum small, obtuse at tips, looks like a knob. Ventral margin of the rostrum deeply and simply concave and not sinuate even near the rostrum. There is marked convexity at the base of the small antennule. Median carina on posterior surface of head continued into a mound between tips of antennules. Fornix strongly prominent and terminating behind on each side in a well marked sharp corner. Valvular part of the shell (carapace) when seen laterally is broadly oval in outline, with stout spine not longer than $\frac{1}{4}$ of the valve length. Spine thickened at its base and arises dorsally from the middle axis of the body. There is a slight bulging of shell, at the ventral side near the joint of spine. A distinct notch by which the dorsal part of head is demarcated from the carapace. Denticles on the dorsal edge long, thick and overlapping, extending below the well marked notch. Ventral edge denticles extends slightly more than $\frac{1}{2}$ length of the carapace. The denticles are most heavily set on the shell spine. Postero-dorsal edge of the postabdomen deeply sinuated beyond middle dividing the denticles in two sets. Anterior set with 5-6 curved and thick based anal denticles. Posterior set with 4-5 straight denticles. Claw with three pecten, all unequal size. Proximal pecten with 10-12 teeth, circularly arranged; middle pecten with rather thick, large 21-23 teeth of which first 3-4 are much smaller; distal pecten with numerous thin, equal sized teeth. Two ephippial eggs present, lying at right angles to the dorsal margin. Tips of eggs strongly pointed, coming out above the level of the ephippium at lateral margin. Ephippium reticulated with dense circles. Four abdominal process present. First large and turned upward, second hook-shaped turned downward, with dense hairs all over. No parthenogenetic female present in the collection. All females either bearing mature, dark brown ephippium or with developing (two) ephippial eggs.

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[1] Accepted September 1985.

[2] Zoological Survey of India, Central Regional Station, Jabalpur, Madhya Pradesh, India. *Present address*: Zoological Survey of India, 933-A, Shivaji Nagar, Pune 411 016.

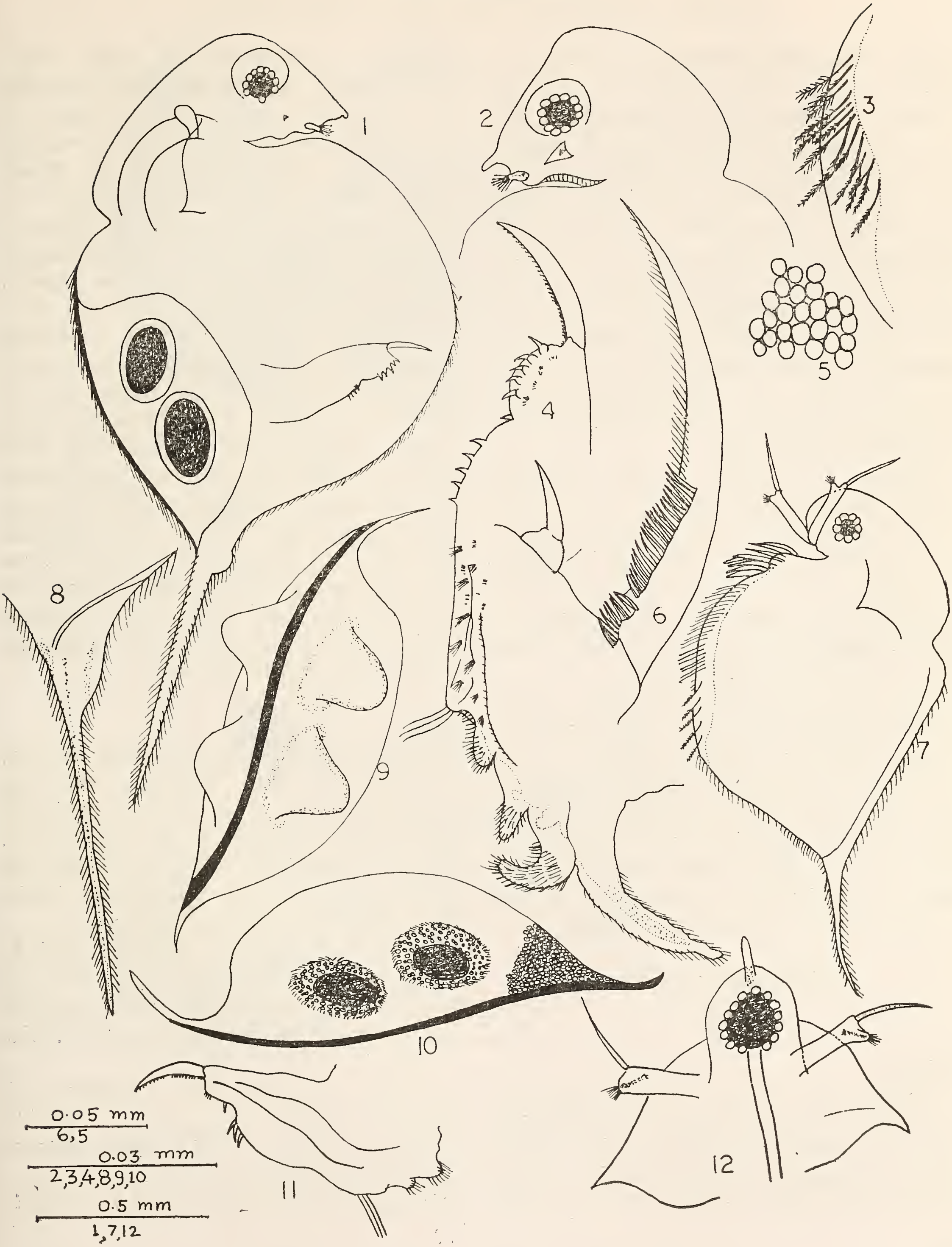
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Fig. 1. (1-12). *Daphniopsis sumanae* sp. nov.
1. Ephippial female; 2. Head of female; 3. Ventral margin of male; 4. Postabdomen of female; 5. Carapace marking in ephippial female; 6. Claw of female; 7. Male; 8. Shell spine; 9 and 10. Ephippium, dorsal and lateral view; 11. Male postabdomen; 12. Dorsal view of male head.

Length of the ephippial female—2.44 mm.

MALE

Similar to female in general shape of the body. Size 1.18 mm. Head almost as long as one third of valves. Fornix highly expanded. Eyes comparatively larger than the females, with several refractive bodies. Antennule with large flagellum narrowing evenly to the distal end. The inner tip of the ventral margin of valve has a dense row of feathered setae along 2/3 of its length. Postabdomen with small reduced abdominal process. Dorsal side of the postabdomen sinuate, with rather small 6-7 anal denticles. Pectinate claw. Some specimens have one spine above the head.

Holotype. ♀ INDIA: Madhya Pradesh, Mandla district, a ditch about 30 cm. depth in the Narmada river at Sahastradhara about 6 km. North of Mandla, 17.12.80, (P. D. Rane), C. 3474/2.

Allotype: ♂, (same data as holotype), C. 3475/2. *Paratypes*: 17 ♀♀, 5 ♂♂, (Same data as holotype), C. 3477/2.

Comments. The species shares the generic character of *Daphniopsis* Sars, 1903, namely a distinct notch by which the dorsal part of the head is demarcated from the carapace. The new species comes close to *D. studeri* Rühe, 1914 but it differs by its broad ephippium and more pointed eggs. Several plumose setae at ventral margin of male valve is also a unique character for the new species.

Daphnia sarojae sp. nov.

(Fig. 2)

FEMALE.

Carapace, seen laterally, rounded and oval in outline, with the spine generally long, more than 1/3 of the valve length and slightly turned obliquely upwards, issuing somewhat above the axis of the body; denticles of dorsal edge extending beyond the cervical region, denticles of ventral edge starting almost from the join of head and carapace. Head of moderate size and defined from the carapace above by a slight concavity of the dorsal margin; Helmet may be present in early developing stages. Eye and ocellus of moderate size. Rostrum small, pointed. Ventral margin of head concave and sinuate near the rostrum. Antennule small, knoblike. Fornix well developed. Carapace distinctly reticulated all over by deep rectangular and squarish cells. Dorsal edge of postabdomen straight but not sinuate. There are above 10-12 anal denticles. Claw straight, pectinate, with proximal and distal pecten. Proximal pecten with 8-9 teeth arranged in half circles, distal pecten with 18-19 large equal teeths. There are fine hairs extending from distal pecten to the end of claw. Three haired abdominal process present. Intestine opens near the base of the claw. Ephippial female was not recorded in the collection. Length of the female, 2.2 mm.

MALE.

Similar to female in general shape of body, size about 1.4 mm. Antennule with long flagellum narrowing evenly to the distal end, large eye, no abdominal process and hook at first leg. Post-abdomen much narrowed, with small four spines near $\frac{1}{4}$ region of dorsal side. Claw with pecten. Rostrum obtuse.

Holotype. ♀, INDIA: Madhya Pradesh, Jabalpur, Rain puddle near rice field on Shahpura Road about 6 km. from Jabalpur near Tewar village. (P. D. Rane), 25.6.1983, C. 3478/2.

Allotype. ♂, (Same data as holotype), C. 3479/2.

Paratypes. 95 ♀♀, 4 ♂♂ (Same data as holotype) C. 3480/2.

Comments. This form is allied to *Daphnia*

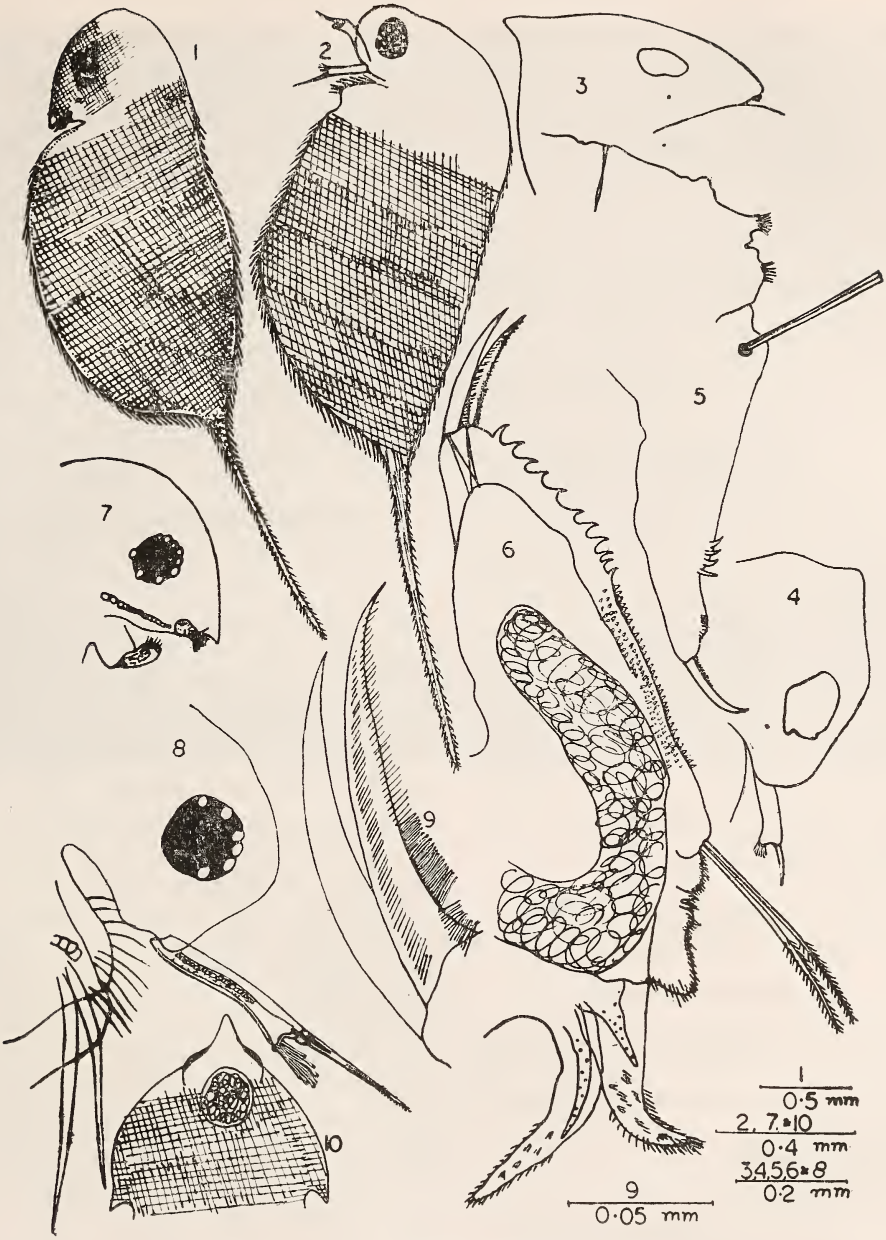
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Fig. 2. (1-10). *Daphnia sarojae* sp. nov.
1. Parthenogenetic female; 2. Male; 3. Immature female; 4. Immature male; 5. Postabdomen of male; 6. Postabdomen of female; 7. Head of female, lateral view; 8. Head of male, lateral view; 9. Claw of female; 10. Dorsal view of female head.

lumholtzi Sars, 1885 but differs conspicuously in broader valves and arrangement of denticles on ventral and dorsal valves. The reticulation of the carapace with very distinct rectangular cells is a unique character of the new species.

ACKNOWLEDGEMENTS

There are due to Officer-in-Charge, Central Regional Station, Zoological Survey of India for providing facilities. I am also grateful to Shri Satish Fadnavis, departmental artist, for his kind help in making the illustrations.

A NEW SPECIES OF A PODOCOPAN OSTRACOD, FROM THE EAST COAST OF INDIA[1]

C. ANNAPURNA AND D. V. RAMA SARMA[2]

(*With a photograph and eight text-figures*)

INTRODUCTION

While studying the ecology of the benthic ostracods inhabiting marginal water bodies on the east coast of India, a new species of podocopan ostracod belonging to the genus *Atjehella* was collected from the backwaters of Bimili (lat. 17°54′N and long. 83°28′E) and in the lower reaches of the Vasishta Godavari estuary (lat. 16°18′N; long. 81°42′E). So far, only one species of *Atjehella* is on record (Kingma 1948).

Family: CYTHERETTIDAE Triebel, 1972
Genus: *Atjehella* Kingma, 1948

Key to the species of *Atjehella*

1. Surface of carapace sculptured with 3 or 4 longitudinal ridges 3
2. Surface of carapace sculptured with numerous longitudinal ridges 4
3. Merodont type of hinge 5
4. Amphidont type of hinge 6
5. Branching marginal pore canals *Atjehella semiplicata*
6. Simple and straight marginal pore canals. *A. multicostatum*

Atjehella multicostatum sp. nov.

(Photo 1; Figs. 1-8)

Carapace laterally compressed, valves heavily calcified and very shallow in lateral view. Anterior end broadly rounded, posterior end less rounded than anterior end. Dorsal and ventral margin nearly straight and converging slightly towards the posterior end. Carapace ornamented with numerous longitudinal ridges on posterior half of the shell. Hinge amphidont type, 3 sockets are connected by a crenulate bar. Inner lamella wide anteriorly and ventrally. The line of concrescence coincides throughout with the inner margin, runs an irregular course with a prominent ventral loop. Marginal pore canals 10 in number at the anterior end. Marginal pore canals simple and straight; normal pores few, scattered and open. Central muscle scars in a vertical row of 4 adductor scars. Eye spots absent. Left valve slightly larger than right.

Length: 0.52 mm; *Height*: 0.33 mm.

Antennule 6-jointed, second podomere bearing tuft of hairs dorsomedially, third podomere

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[1] Accepted September 1985.

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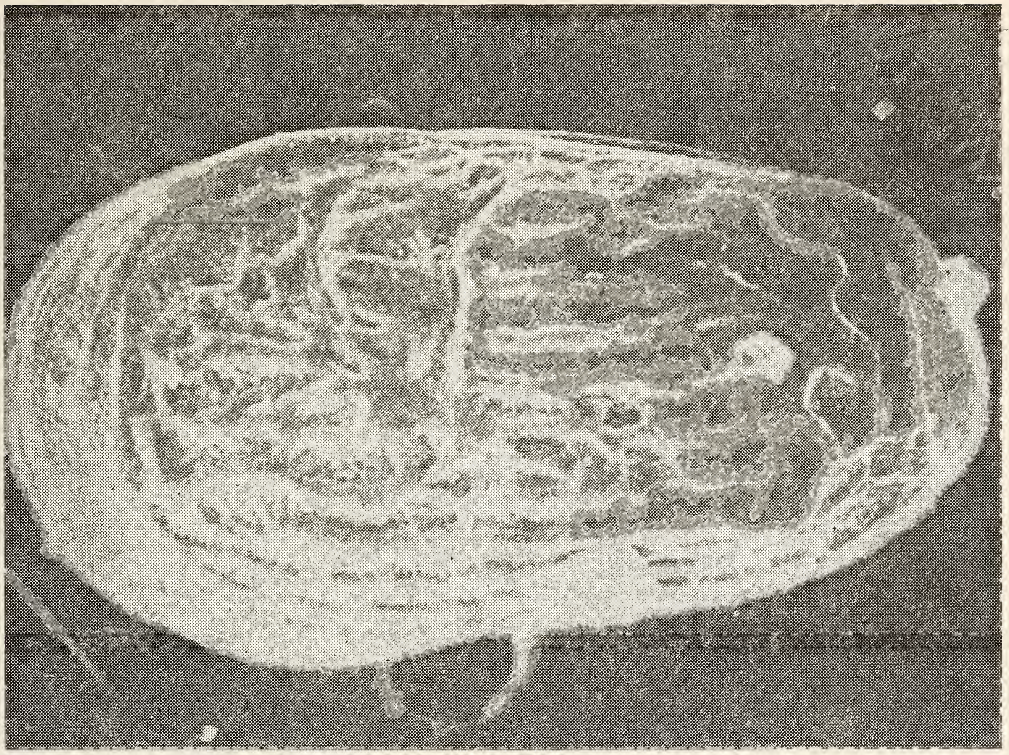


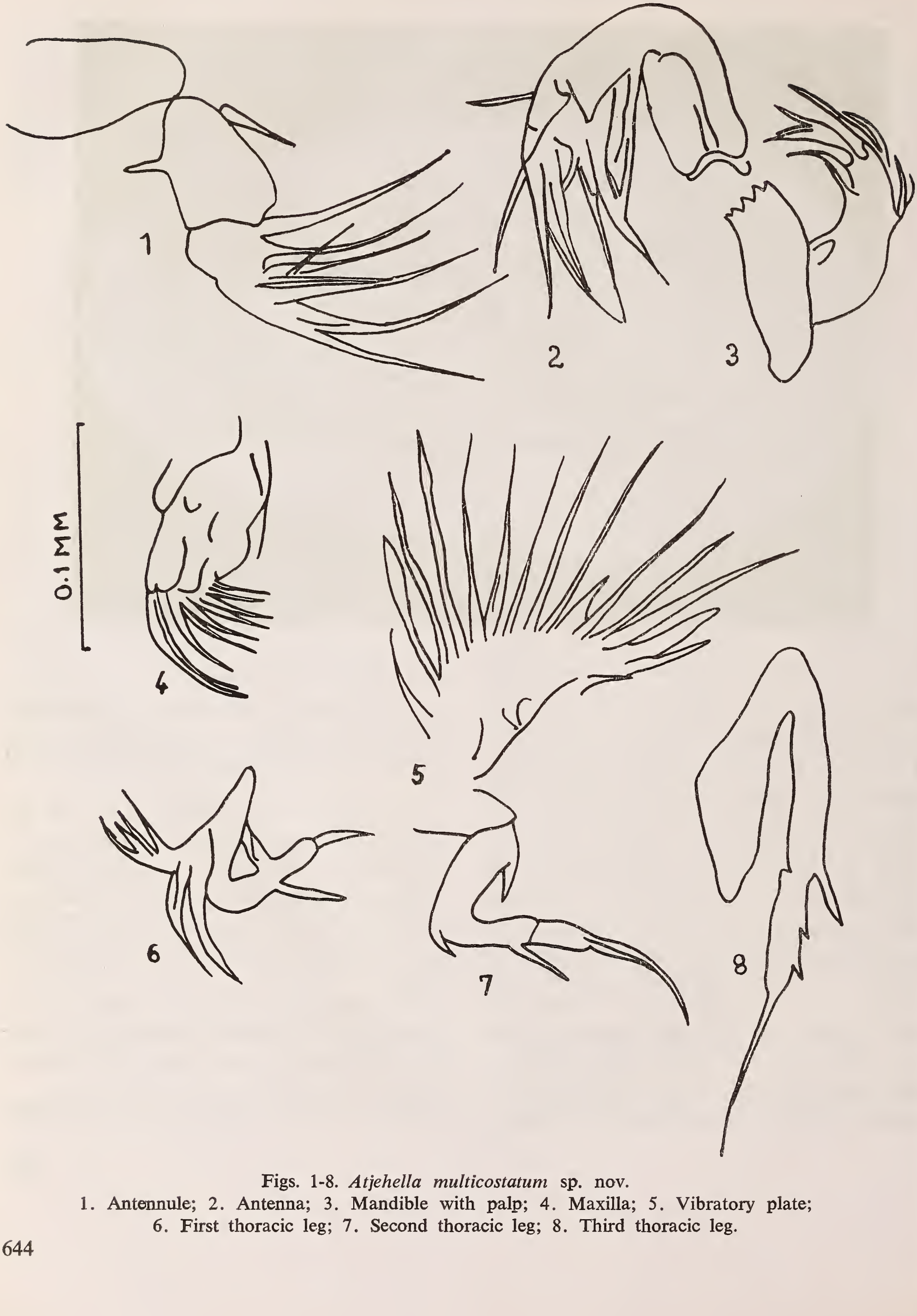
Photo. 1: *Atjehella multicostatum* sp. nov. — exterior view of left valve.

bulbous and short. Consists of 2 claw-like setae, fourth podomere narrow and consists of 4 claw-like setae and slender setae arranged between the claws. Antenna 6-jointed, distal ends of first segment with 2 claw-like setae, ultimate podomere with 2 pairs of claw-like setae, the slender setae, arranged between the claw-like setae. No spinneret seta. Mandible with 6 pairs of teeth arranged laterally on the cutting edge. Mandibular palp 3-jointed. First segment bulbous. Ultimate segment with slender setae. Maxilla with 3 masticatory lobes, narrow and elongated masticatory lobes end with elongated slender setae. Vibratory plate well developed with 15 unfeathered rays. In first thoracic leg, endopodite develops as palp — a characteristic feature of the family Cytherettidae. Second and third thoracic legs each with 3 podomeres, ends with curved claws.

Remarks: In the general shape of the carapace *A. multicostatum* is similar to *A. semiplicata* as illustrated by Kingma (1948). It differs from it in the presence of numerous longitudinal ridges, amphidont type of hinge and the marginal pore canals being simple and straight.

The name of the species is based on the characters of systematic importance, *viz.* surface of the carapace sculptured with numerous longitudinal ridges.

Type specimens: Holotype and 2 paratypes



Figs. 1-8. *Atjehella multicostatum* sp. nov.
1. Antennule; 2. Antenna; 3. Mandible with palp; 4. Maxilla; 5. Vibratory plate; 6. First thoracic leg; 7. Second thoracic leg; 8. Third thoracic leg.

are deposited in the National Collection, Zoological Survey of India, Calcutta, India.

Type locality: Bimili backwater.

Occurrence: Backwaters of Bimili and Vasishta Godavari estuary, east coast of India.

ACKNOWLEDGEMENTS

We thank the Head of the Department for facilities. We are thankful to Prof. M. Subbarao, Geology Department of Andhra University for his interest and encouragement in this work. One of us (CA) is grateful to the CSIR, New Delhi for financial assistance.

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TWO NEW SPECIES OF ORIBATIDS (ARACHNIDA: ACARINA) FROM SOUTH INDIA[1]

M. M. BALAKRISHNAN[2]

(*With seven text-figures*)

Two new species of oribatid mites, *viz. Mixacarus quadrifasciatus* sp. nov. (Lohmanniidae) and *Neogalumna curviporosa* sp. nov. (Galumnidae) are described with illustrations. Both the genera are new to India.

Mixacarus quadrifasciatus sp. nov.
(Figs. 1-3)

Dimensions: Length: 800-928 (852.5) μ; width: 432-480 (444) μ; height: 320 μ.

Prodorsum (Fig. 1): Broadly triangular, ornamented with rounded or irregular foveolae and small circular areae porosae; lamellar (*la*) and interlamellar (*in*) hairs almost equally long; rostral (*ro*), anterior exobothridial (*exa*) and posterior exobothridial (*exp*) setae short and of squal length; all prodorsal setae with minute barbs; sensillus (*ss*) with 11-12 branches, of which the proximal one and distal two being very short (fig. 2); a transverse ribbon-like band present posterior to the level of *in*.

Notogaster (Fig. 1): Lateral margins more or less parallel; posterior margin slightly wavy; surface with closely set rounded or irregular foveolae and scattered small circular areae porosae; four transverse bands present, probably S_2, S_3, S_5 and S_6; S_2, S_3 and S_6 incomplete; S_5 complete with the middle portion curved posteriorad; sixteen pairs of setae, all with minute barbs; lateral setae longer than the median ones.

Ventral side (Fig. 3): Infracapitulum punctate, with 4 pairs of unilaterally barbed setae and a few small circular areae porosae; epimeral setal formula 3-1-3-4, all setae short and provided with minute barbs; coxisterna I with 6-11 small circular areae porosae; genital setal formula 6+4; pre-anal plate widest

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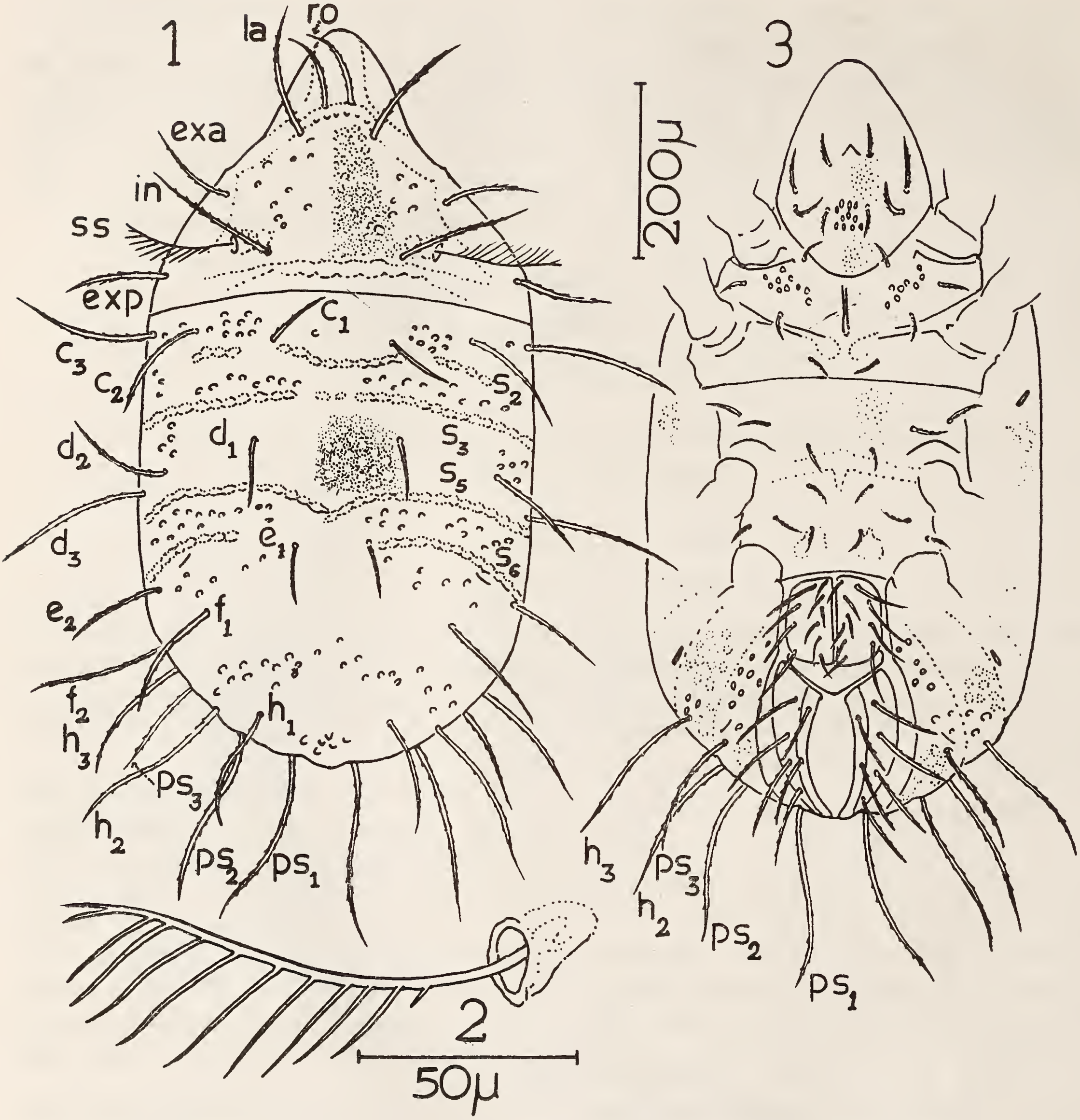
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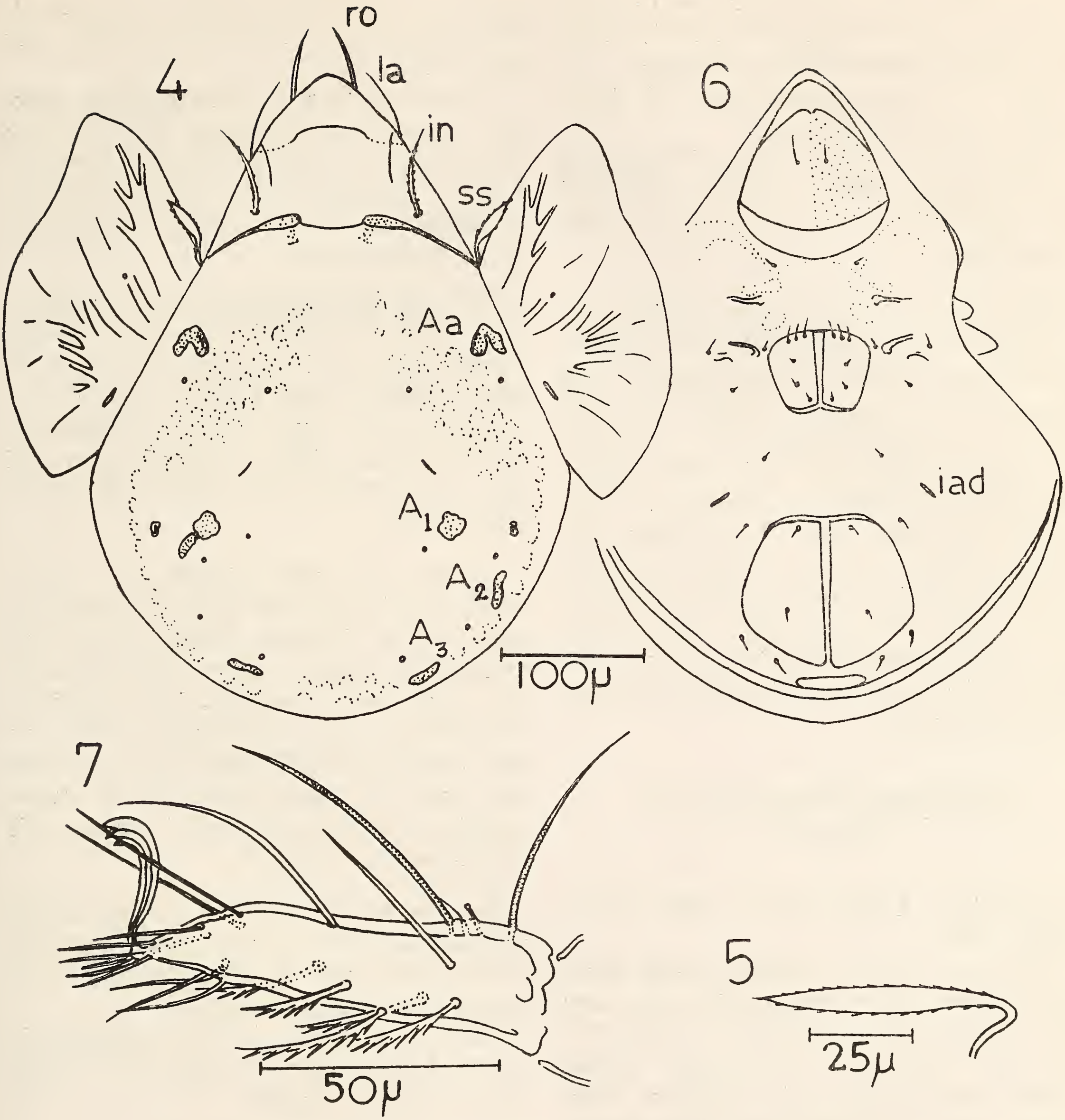
Figs. 1-3. *Mixacarus quadrifasciatus* sp. nov.
1. Dorsal side; 2. Sensillus; 3. Ventral side.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Figs. 4-7. *Neogalumna curviporosa* sp. nov.
4. Dorsal side; 5. Sensillus; 6. Ventral side; 7. Tarsus I.

in the middle; two pairs of anal and 4 pairs of adanal hairs, all unilaterally barbed; adanal setae slightly longer than the anal setae.

Legs: All legs monodactylous; left leg I with 2 claws in one paratype.

Holotype ♀. INDIA. Kerala, Tunakadavu (Nelliyampathy Hills), collected from leaf litter on forest floor. 10.v.1982. Coll. M. M. Balakrishnan.

Paratypes 3 ♀ ♀, data same as for holotype.

Remarks: The genus *Mixacarus* is hitherto known from 8 species: *M. integer* Balogh, 1958 from Africa, *M. hammani* Balogh, 1961 from Java, *M. neotropicus* Balogh, 1962 from Peru, *M. chapmani* Wallwork, 1962 from Ghana, *M. exilis* Aoki, 1970 from Tsushima, *M. vanhonggui* Mahunka, 1973 from Korea, *M. brevipes* (Banks) Norton, 1978 from North Carolina and *M. zhuzhikovi* Bulanova Zakhvatkina, 1979 from the USSR. The present species can be distinguished from all its known congeners by the presence of 4 transverse bands on the notogaster.

Neogalumna curviporosa sp. nov.
(Figs. 4-7)

Dimensions: Length: 510 μ; width: 357 μ; height: 293 μ.

Prodorsum (Fig. 4): Surface smooth; interlamellar setae slightly long; lamellar setae very thin; rostral setae originating in front of a transverse elevation; dorsosejugal suture arcuate; areae porosae dorsosejugales long; sensillus with a short stalk and long spindle-shaped head provided with barbs (fig. 5).

Notogaster (Fig. 4): Integument with irregular and diffuse foveolae disposed laterally and posteriorly; ten pairs of alveoli; four pairs of areae porosae; *Aa* ribbon-shaped and curved; A_1 irregularly rounded; A_2 and A_3 ribbon-shaped (A_2 of left side was seen very close to A_1).

Ventral side (Fig. 6): Infracapitulum punctate; epimeral and anogenital regions smooth; circumpedial lines distinct; six pairs of genital, 1 pair of aggenital, 2 pairs of anal and 3 pairs of adanal setae; *iad* off anus; postanal area porosa ribbon-shaped.

Legs: All legs tridactylous and heterodactylous; tarsus I (fig. 5) becoming narrower abruptly after $\frac{3}{4}$ of its length; a total of 23 hairs present on tarsus I.

Holotype ♀. INDIA. Kerala, Tunakadavu (Nelliyampathy Hills), collected from leaf litter on forest floor. 10.v.1982. Coll. M. M. Balakrishnan.

Remarks: The genus *Neogalumna* is represented only by the type species *N. antenniger* described by Hammer (1973) from West Samoa. The present specimen differs from the type species in the presence of (1) prominent interlamellar setae, (2) sensillus with short stalk and long spindle-shaped head provided with barbs, (3) long areae porosae dorsosejugales, (4) long and curved *Aa* and (5) ribbon-shaped A_2 and A_3.

Since the lamellar setae of both the species of *Neogalumna* are very thin when compared to the rostral setae, it seems justifiable to be treated as a generic character.

The type specimens are to be deposited in the Zoological Survey of India, 34, Chittaranjan Avenue, Calcutta.

ACKNOWLEDGEMENTS

I am grateful to the Head, Department of Zoology, University of Calicut, for facilities, to Dr. M. A. Haq for encouragement and to the University of Calicut for financial support.

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REVIEWS

1. POPULATION DYNAMICS OF RABIES IN WILDLIFE. Edited by Philip J. Bacon. pp. 349 + index (23 × 15.5 cm), with several text-figures. London, 1985. Academic Press Inc. Price not mentioned.

Rabies has been known since the dawn of history and is traditionally associated with dogs to such an extent that, in many parts of the world people are still not aware that rabies can be caused by animals other than dogs.

In fact, rabies can infect any warm blooded animal, and any infected animal, not excluding man, can transmit the disease to others. However, the dog remains the main reservoir and vector for transmission of this disease, and European countries, which have efficiently eliminated stray dogs have kept themselves free of this disease for the greater part of the present century. Wild animals do suffer from rabies but they impinge of human communities so rarely as to remain something of a curiosity.

In most of the developing world, where dog rabies is still the predominant source of infection, wild animal rabies is of only academic interest. However, in recent years particularly after the war of 1939-45 there appears to be an upsurge of wild animal rabies in Europe and studies made in western Europe show that the main vector of this disease is the red fox. This animal is found over most of Europe inhabiting mainly open scrub land, and hilly areas where little or no agricultural activity takes place. In recent years, the number of foxes dying of rabies has increased, and incidents of foxes attacking dogs, livestock, and even man have been increasing. Rabies infection in these animals appears to be spreading gradually southwards. The first records were from Scandinavia and North Germany. Later rabid foxes have been reported in France and as far south as northern Italy.

In the beginning efforts were made to control this spread of rabies by shooting the fox, but it soon became evident that this was not the answer. When foxes were shot, there was a temporary depletion of the fox populations, but a few months later more foxes drifted in from surrounding areas to restore the populations. Complete extermination is neither practical on a continental scale, nor desirable ecologically. It was therefore felt that efforts should be made towards containment of the fox population, and to control the spread of rabies in this population. One of the efforts, not described in the book under review was the immunization of foxes by putting out baits containing oral rabies vaccine. This is reported to have been very successful in Switzerland but the scientific follow up reports are still not available.

Under these circumstances it was felt that an effort to understand the mode of spread of rabies in the fox population and its rate of advance would help us to determine what sort of control measures are likely to give the best results. The use of mathematical modelling where, in a model, change of one or more parameters can indicate the sort of end result such a change would produce, would be of help in determining what measures to use. Preparation of such models requires not only close collaboration between biologists and mathematicians but needs certain background information such as the rate at which breeding occurs, i.e. the rate at which new susceptibles are added to the population, the actual incidence of rabies in the population at a given time, the frequency of infection occurring in the population, etc. Most of these are unknown. Despite this efforts have been made by assigning arbitrary values or 'guesstimates' to some of these factors, to devise models, spatial as well as temporal, for estimating the spread of rabies in the red fox population and how the modification of various factors involved in the model would affect the outcome. Various types of models are presented in this book, and effects of various manipulations have been extrapolated. Since the factors required in preparing the original model are not exactly known these models and their predictions have to be tested in the field to establish whether, and to what extent, they correspond to what happens in nature.

Mathematical modelling is a fascinating exercise, and when the basic presumptions correspond with the facts, can give surprisingly clear quick answers to questions posed. However, in the present instance where many of the basic parameters are unknown, it becomes an exercise of preparing a model with a given set of parameters and seeing how it would progress with time or in geographical space if these parameters continue to remain in force. The result of such extrapolation is compared with observed phenomena. If the correspondence with observation is close, one may take it that the assumed parameters were near enough to the truth. If it does not correspond to observed phenomena, the parameters may be redesigned or modified to get a more suitable fit. The models presented in this book, and the simulations based on extrapolations of these, are of great interest to all those involved in these disciplines as well as to biologists concerned with the problems of spread of rabies. As such it forms a useful contribution for epidemiological research, enabling us to decide what type of action would be most fruitful in preventing further spread of disease.

Mathematical modelling can be applied to many types of problems, and its usefulness in wildlife studies is only beginning to be explored. The models presented deal solely with the problem of rabies in the red fox in Europe. The introductory chapters however give an excellent overview of the knowledge about rabies in Wildlife in different parts of the world.

A. N. D. NANAVATI

2. FIELD GUIDE TO THE COMMON TREES OF INDIA. By P. V. Bole and Yogini Vaghani. pp. xxiii + 125 (18 × 11.5 cm) with line drawings by Yogini Vaghani. Bombay, 1986. Oxford University Press for World Wildlife Fund - India. Price Rs. 18.50.

The problem faced by beginners is, how to identify plants and which books should they refer to. There are hardly any book suitable for amateurs on identification of Indian plants. The 'Field Guide to the Common Trees of India', is a welcome attempt to help amateurs. The book describes briefly about hundred of the most common trees of the Indian plains and foothills including some of the trees introduced into India from other parts of the world. Each description is accompanied by a line drawing to assist in identification. But the drawings are very disappointing. There is no comparative scale for flowers, fruits, etc and this leads to misinterpretation.

However an interesting feature is the key to the identification of the trees described in the text on the basis of the branching, leaves, stipules, spines etc. It would have been more useful if in the beginning a few pages depicting different parts of plants, and shapes and types of leaves had been included. The book also has a colour classification of flowers, which should be very useful during the flowering seasons. The book has a well chosen glossary and index of both common and latin names.

There are several typographical errors. The key on page 7 (line 14) is erroneous and difficult to understand. It is indeed very difficult to choose hundred common trees from the several thousands found in India and to prepare a simple key for the same. It may also happen that several closely related species may have similar features and may lead to erroneous identification.

MEENA HARIBAL

MISCELLANEOUS NOTES

1. A NOTE ON THE INTERACTION OF COMMON LANGUR (*PRESBYTIS ENTELLUS*) AND WOLF (*CANIS LUPUS*)

In the early morning of March 7th 1986, I (BRM) was observing an all male langur troop at Nahargarh Reserve forest, about 10 km from Jaipur city, feeding on the leaves of *Anogeissus pendula.* Suddenly one animal gave an "Alarm bark", and all members of the troop became alert, and peered towards the nearby hills. I saw a wolf (*Canis lupus*) sitting on a rock. The langurs started jumping from branch to branch and came very near to the wolf, and started barking. Initially, for more than half-an-hour, the wolf was quiet. Then the wolf started reacting. The langurs were frightened, and climbed up to the top of the trees. However they continuously barked and tried to chase the wolf and followed, it as the wolf moved out of the area. No case of such interaction appears to have been reported so far.

B. RAM MANOHAR
REENA MATHUR

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UNIVERSITY OF RAJASTHAN,
JAIPUR-302 004,
May 7, 1986.

2. SIGHTING OF AN UNKNOWN SPECIES OF CAT

Returning from Hayuliang in the eastern Mishmi hills of Arunachal Pradesh on the road to Teju and some 15 km from Hayuliang, I came across on the road at night, a darkish rusty-brown cat about the size of the domestic cat but longer and with a long and prominent tail. The animal was distinctly visible at close range in the powerful beam of the jeep lights. It was marked with chocolate brown spots but not very prominent, the size and the number of spots increasing from the front portion of the body towards the hind portion, the tail being very prominently marked by rings of the same colour. I have not seen a cat of this kind and have not heard of one such being reported. It was not a domestic cat because firstly the Mishmi tribes there do not keep domestic cats and in any case the sighting was quite far from any habitation and what clinched the issue was the fact that some 2 km further up I saw an identical specimen again. The closest in resemblance is the rusty spotted cat, but it was a little different, especially in the matter of rings around the tail and I am not aware of any rusty spotted cat being reported anywhere in that region or for that matter in eastern India.

M. K. RANJITSINH

JOINT SECRETARY,
DEPTT. OF ENVIRONMENT
& FORESTS,
(WILDLIFE WING),
KRISHI BHAVAN, NEW DELHI,
May 24, 1986.

3. NOTE ON INDIAN WILD DOGS (*CUON ALPINUS*) IN SARISKA NATIONAL PARK

(*With a plate*)

Sariska has traditionally been the hunting preserve of the Maharajas of the erstwhile state of Alwar in Rajasthan. To the best of my knowledge there is no authenticated record of wild dogs in the area during the Maharaja's time or later. I have been visiting these forests since 1972 and neither have I come across wild dogs on my various visits, nor have I heard reports of their occurrence during this period.

Some few weeks back I received information that 3 wild dogs had been seen inside the National Park. I was in Sariska on 23rd and 24th April when this report was confirmed by the forest department staff and the wild dogs have been seen on kills of sambar and cheetal fawns. On 24th April, I was sitting in the hide on a water hole at Kalighati. At 5.00 p.m. there were about eight cheetal and four sambar at the waterhole with an assortment of peafowls, tree pies, crows, etc. Suddenly a sambar and a cheetal gave alarm calls and all of them bolted and the birds flew off instantly as would happen on the arrival of a large predator. Within seconds a female wild dog arrived, entered the water, sat in it and quenched its thirst. She remained there for about five minutes and departed. While the sambar and cheetal again arrived within minutes of the departure of the wild dog, there was no sign of the other two wild dogs until I left the hide at dusk around 6.30 p.m.

In sharp contrast, the arrival of a jackal earlier at 4.30 p.m. caused no commotion among the prey population, and infact the former had to demonstrate and charge the sambar and cheetal to shoo them off the water hole.

As far as wild dogs are concerned, I am told that they were found in and around the present Ranthambor National Park but not in the last 30 years or more. It would be interesting to know if there are any reports of these animals in the vicinity of Sariska to find out where the three animals in question came from.

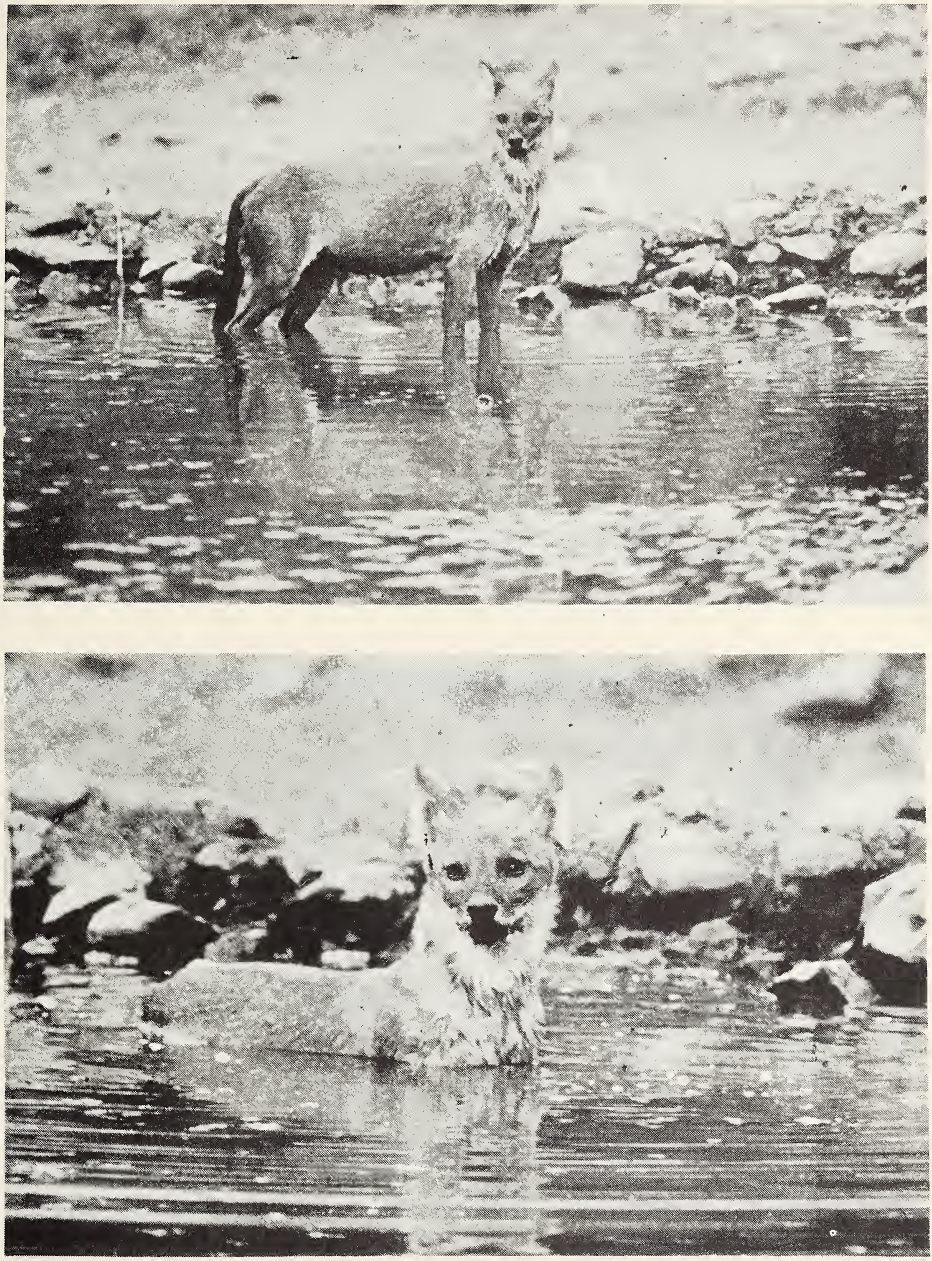
No. 1, Mansingh Road,
New Delhi-110 011,
June 4, 1986.

DIVYABHANUSINH

4. SOME NOTES ON FIELD BIOLOGY OF *RHOMBOMYS OPIMUS*, *MERIONES PERSICUS* AND *MUS MUSCULUS BACTRIANUS* WITH REFERENCE TO ORCHARDS OF BALUCHISTAN (PAKISTAN)

Introduction

The Great Gerbil or the Giant Day Jird (*Rhombomys opimus* Lichenstein, 1823), the Persian Jird (*Meriones persicus* Blandford, 1875) and the House Mouse (*Mus musculus* Linnaeus, 1758; *M. m. bactrianus* Blyth, 1846, the Persian House Mouse) are known from Baluchistan through some casual distributional notes and some occasional ecological inferences



Indian Wild Dog (*Cuon alpinus*) in Sariska National Park.
(*Photos:* Author)

mostly drawn from the generalizations based upon the studies from other regions (Roberts 1977). During the course of our studies on the biology of vertebrate pests of orchards of Baluchistan (Mian and Ali in press, Mian *et al.* in press) limited data was collected on these species which is being presented here.

METHODS AND MATERIALS

A total of 30 individuals of *R. opimus* (Quetta valley, 5; Mustung, 16; Gulistan, 9); 10 specimen of *M. persicus* (Ziarat, 8; Chaotair, 2) and 10 individuals of *M. m. bactrianus* (Quetta valley, Ziarat and Choatair) were trapped from the localities mentioned against each with the help of steel snap traps. The individuals were brought back to the laboratory and were sexed, weighed and analysed for various ecological parameters as per methods outlined in Mian (1986, in press). Sokal and Rohlf (1969) was followed for statistical analysis.

RESULTS AND DISCUSSION

Rhombomys opimus:

All the 30 individuals of this species were trapped from apple orchards during winter months (November through January, no trapping being undertaken in these areas in other parts of the year). Quetta valley, Mustung and Gulistan, share a common character in having loose sandy soil, steppic vegetation and an altitudinal location ranging from 1500-2000 m above sea level. This habitat is in conformity to the one described by Roberts (1977) for this species, in general. However, Roberts (1977) has not marked these areas in the tentative distribution map which mostly restricts the distribution of the species to the border area of north east Chagai (southwestern Baluchistan). Further, the species in Pakistan has been associated with uncultivated patches of steppic vegetation and hence was considered as of no economic importance. The present trapping of the species from orchards, hints at the importance of this species as a potential pest to orchards or other irrigated plantations. Further data is needed in support or otherwise of the present information. The species may also pose a potential threat to the small earth filled dams which play an important role in the economy of the area.

Our trapping data suggests that there is a gross imbalance in the sex ratio exhibited through our total sample (25 males: 5 females; Male: Female sex ratio, 5:1) and in the different samples collected from different localities (Quetta, 4 males: no female; Mustung: 14 males: 3 females; Gulistan, 7 males: 2 females). This imbalance in sex ratio can be attributed to a number of factors, including the higher population of the males in winters, trap shyness of the females, larger home range of males, males being more attracted to the cultivated tracts of the apple orchards and males being more exploratory in habit than females. The present data is insufficient to lend support to any of these alternative hypotheses.

The fairly high trap success (0.0156 individuals/trap/day) shown in the winter may indicate that the species does not hibernate during the cold winter months. This observation partially confirms the earlier report of Sokolov (1963) suggesting that the species will feed above ground even when there is snow on the surface.

None of the females trapped (total of 5) during our sampling period was reproductively active indicating that there is no reproductive activity during the winter months.

Meriones persicus:

10 specimens (6 ♂♂ and 4 ♀♀) were trapped from the valleys located at higher altitudes, in forests of *Juniperus macropoda* and were equally shared in the two seasonal samples, i.e., May and July. Out of the two females trapped during May, one was pregnant with three embryo (2 in the left uterine horn and one in the right, average weight of the embryo was 0.46 g). The other female collected in July had a vaginal plug indicating a recent mating.

Mus musculus:

A total of 10 specimens of the House Mouse were trapped from Quetta valley (2), Ziarat (6) and Chaotair (1) during the summer months, i.e., April to July. The absence of the individuals of this species in the samples collected in other parts of the year specially in those collected from Quetta valley is rather hard to explain. It is quite possible that the species remains underground where it depends upon the stored food collected in the burrows or in the godowns established in human settlements (Roberts 1977).

M. m. bactrianus is very widely distributed and is usually associated with human settlement (Roberts 1977, Taber *et al.* 1967) though it has been trapped at a distance of 4 miles (more than 6 km) from the nearest human habitation. The presence of this species in orchards may also be due to their association with human settlements in the vicinity of orchards.

In the overall sample 4 males and 6 females were trapped. Out of the 6 females captured 3 had vaginal plugs, indicating a recent mating and another had a visible pregnancy. The pregnant/potential pregnant females were equally distributed in the samples collected in the months of April, May and July. One of the pregnant female had 6 embryos in the uterus (2 on the right side and 4 on the left side). This is in conformity with the one recorded by Roberts (1977), who suggested an average size of 5 embryos per female for this species/subspecies.

ACKNOWLEDGEMENTS

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AFSAR MIAN

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5. ASSOCIATION OF *NESOKIA INDICA* GRAY WITH MICROFLORA AND FAUNA OF ITS BURROW SOIL AND DROPPINGS

INTRODUCTION

The habits and habitats of rodents are often very different and is reflected in the flora and fauna of burrows. *Nesokia indica* G. a field rat, inhabits bunds of field, banks of water channels and occasionally flat fields. Rodents in general are considered to be carriers of diseases. The studies on the microflora and fauna were, therefore, conducted to investigate whether or not *N. indica* is associated with pathogens affecting human, plant and the rat itself.

MATERIALS AND METHODS

a. Microflora

1. *The fungal flora of rat burrows*

For the isolation of soil fungus a method described by Waksman (1927) was followed. Soil samples from various burrows situated in irrigated and non-irrigated areas were collected and mixed thoroughly. Soils around the burrows were also collected and mixed thoroughly, these samples served as control.

Potato dextrase agar (P.D.A. containing 200 g Potato extract, 20 g agar-agar, 20 g dextrose and 3.3 ml of 1% Rose Bengal in 1 litre) media sterilized by autoclaving at 151b for 20 min. was used for plating. Each plate held 20 ml of medium soil samples which were plated by direct method and the plates were incubated at 25°C for one week. These plates were examined for colonies of fungus. Two replicates were maintained for each set. The fungi were isolated and identified.

2. *Isolation of fungi from rat droppings*

Droppings were collected from various burrows and were powdered. The same technique as described above was adapted for fungi isolation and identification.

b. Fauna of rat burrows

1) Nematodes:

The method included the following steps: (i) Extraction, (ii) Killing, (iii) fixing and identification.

i) *Extraction of nematodes.*

Soil samples used here were same as that for fungal studies. Samples were processed by 'Cobb's modified sieving and Baermann funnel technique (Christie and Perry 1951). 20, 60, 200 and 325 mesh sieves were used. In place of the funnel 10 cm diameter petri dishes were used. The catch from all the sieves except 20 mesh sieve was poured over tissue paper (three layered) spread over coarse aluminium gauge touching the water layer in the petri dish (Schindler 1961). This was left for 48h and the suspension containing

TABLE 1

FUNGAL FLORA

(a) Burrow soil	Control *	(b) Droppings
Aspergillus flavus	*Aspergillus flavus*	*Aspergillus flavus*
A. niger	*A. niger*	*A. niger*
A. versicolor	*A. versicolor*	*A. versicolor*
A. terreus	*A. terreus*	*Penicillium* sp.
A. tomori	*A. tomori*	*Trichoderma* sp.
A. sydowii	*Penicillium* sp.	
Penicillium sp.	*Trichoderma* sp.	
Trichoderma sp.		
Cladosporium sp.		
Paccilomyces sp.		

* Soil collected from the vicinity of the burrows.

nematodes was collected and transferred into a bottle and was concentrated by decantation.

ii and iii). *Killing, fixing and identification.*

After decantation, the suspension was transferred to a McCartney bottle and was kept in boiling water for 2 minutes. Then an equal quantity of 5% formalin was added to it. The nematode suspension was observed under a binocular microscope and the identification of nematodes was done upto generic level. A similar procedure was followed for the isolation of nematodes from the droppings.

The burrows were also searched and the presence of various fauna recorded.

RESULTS AND DISCUSSION

Examination of microflora and fauna in soil samples collected from the burrows of *N. indica* has revealed that the burrow soil is rich in flora and fauna. Ten different species of fungi were obtained while there were only 7 found in the soil collected around the burrows. Table 1 shows the various types of flora obtained during the investigation. Most of the fungi are saprophytic, some of them under congenial conditions may cause diseases in certain host plants (Facultative parasites). Urs *et al.* (1966) have also reported different microflora obtained from soil samples of the burrows of *R. rattus, M. musculus, B. indica, B. bengalensis* and *T. indica.* They also report *Aspergillus* and *Pencillium* in almost all burrow soils.

Table 2 shows various types of nematodes, plant parasitic in nature, obtained from the burrow soil. No nematodes were isolated from the droppings. Chakraborty (1975) also found nematodes in the burrow soils of *B. bengal-*

TABLE 2

FAUNA OF BURROWS (NEMATODES)

Burrow soil	Control*
Mononchus sp.	*Mononchus* sp.
Cephalobus sp.	*Cephalobus* sp.
+*Tylenchorynchus vulgaris*	*Dorylaimids* sp.
+*Pratylenchus* sp.	
+*Hoplolaimus indicus*	
Dorylaimids sp.	

* Soil collected from the vicinity of the burrows.
+ Plant parasitic.

ensis, but has not given any account about their role.

Apart from nematodes, isopods, spiders, centipedes, toads, ants, ground beetles, eggs of reptiles, were found in the rat burrows. Nothing specific is known about the role of these organisms on rat activity. However, it was observed that in the burrows, in which spiders were present, the rats had already deserted the burrow. Ants can be also source of nuisance for rats, it is very likely that ants force the rats to keep on changing their abode.

In case of other species of rats, e.g. *B. indica* (Arjunwadkar and Gadgil 1974) and *B. bengalensis* (Chakraborty 1975) some information on the fauna is available. But nothing is known about their role on rat activity. Therefore, it can be concluded that there is a need to investigate the role of microflora and fauna in detail in order to understand their influence on the population dynamics of this pest, and also to human, plant and the rat itself.

ACKNOWLEDGEMENTS

I wish to thank my supervisor Dr. R. N. Katiyar for his valuable guidance during this study. I am grateful to Mr. I. Krishna Murthy for typing this manuscript. This study was done during the tenure of my Masters Degree programme.

P. RAMESH[1]

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June 7, 1986.

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[1] *Present address*: Sorghum Entomology, ICRISAT, Patancheru PO, A.P.

6. A FIGHT BETWEEN BULL GAURS IN MUDUMALAI

On 9.1.86 at 3.30 p.m. while moving on elephant back through compartment 12, we heard animals crashing through and thrashing-bushes Gopan, the Mahout cautiously took his ward Bama to an advantageous place, to have a safe look of what was happening. We saw on a sloping opening 2 bull Gaurs thumping and snorting, near a herd of 14 plus, (Herd marker-old Cow with torn left ear); one bull was young the other, older. There was no appreciable difference in size; the dewlap of the young bull was nearly touching the ground and his dorsal ridge was prominent. The old bull had some identification marks — a pale patch above right carpal joint — a conspicuous dip in the dorsal ridge — his right horn appeared shorter by 2-3 inches than the left, with tip broken and frayed. The young bull exhibited lateral display, turned toward the old bull attacking with low horn threats (18 times). The older bull appeared to retreat, before actual contact of heads (12 times) turned aside; both pushed the head of the other without twisting (5 times) pushed twisting heads (once). It appeared that the old bull wanted to get away, exhibiting submissive gestures and swinging around, when the young bull forged forward. The old bull who first stood on the lower side of the slope; by strategic moves, enticed the young bull to attack, retreated in small semi circles and manoevoured to occupy a position higher than the young bull and stood along the contour. The old bull then started snorting vigorously and thumping, I thought the old bull was preparing to attack but it did not. The young bull responded with thumps and snorts after a lateral display and attacked up the slope. The old bull gave one powerful push and the young bull went crashing (probably rolling) down the slope. It looked that the older bull manoevoured his adversary, cleverly to a lower position where the slope and his own weight acted against the animal and the old bull took advantage of the slope. They had been fighting for about 45 minutes. The next day I located the herd but not the young bull. After two days I saw him limping severely and grazing solitarily, 3 km away from the herd.

J. MANGALRAJ JOHNSON

WILDLIFE WARDEN,
MUDUMALAI SANCTUARY,
UDHAGAMANDALAM 643 001,
TAMIL NADU,
June 26, 1986.

7. INSTANCE OF AN INDIAN PANGOLIN (*MANIS CRASSICAUDATA* GRAY) DIGGING INTO A HOUSE

At about 2 O'Clock on the night of 5/6 October 1984, I and my friend woke up when we heard a 'hiss' from inside a room which had been since long locked up and had an uncemented floor.

On opening the door, we found a long burrow in a corner and an Indian Pangolin (*Manis crassicaudata* Gray) standing nearby. Obviously, it had arrived by burrowing from outside into the house. As the compound fence of the house is not less than 12 feet away from the spot, it should have made a long burrow.

The Indian Pangolin is occasionally seen in the villages near Gwalior and in the Madhav National Park, Shivpuri (M.P.) (Saxena 1985). However, it is the first time that it came into a house ! The pangolin was greenish-brown in colour.

It was captured and sent to the Gwalior Zoo.

RAJIV SAXENA

HANUMAN NAGAR,
PHALKA BAZAR,
GWALIOR-474 009 (M.P.),
July 26, 1986.

REFERENCE

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8. OCCURRENCE OF THE GREAT CRESTED GREBE *PODICEPS CRISTATUS* (LINNE) AT TADOBA, MAHARASHTRA

On December 4th, 1984 while watching a group of Red Crested Pochards *Netta rufina*, on Tadoba lake in Chandrapur district, we saw a whitish thin necked bird having a black crest far away at the center of the lake. Next day while walking along the lake shore we (IIT Wildlife Club) saw the same bird near the pump house often diving into the water and staying as long as twenty to thirty seconds inside the water. It was immediately recognised as a large grebe. We went closed to have a better look and identified it as the Great Crested Grebe *Podiceps cristatus*. This is the first report of its occurrence in Maharashtra (Checklist of the Birds of Maharashtra).

The southern most record of this bird is from Puri (19°40′N and 86° E), in Orissa. Tadoba is 45 kms from Chandrapur, almost on the same latitude (20° N and 79°20′ E), but about 650 km to the west of Puri. It is interesting to note that this species is accepted as winter visitor entering from north-west and going as far as Assam and Manipur in the east and Gujarat in the south. This bird now seems to be visiting new areas where it was earlier unknown (*JBNHS* 80: 414). Maharashtra lies between Gujarat and Orissa. Hence it would be interesting to find out whether it is passage migrant at Tadoba. We were in Tadoba during the next ten days and saw the Grebe every day.

MEENA HARIBAL

4, MODI NIVAS,
TELANG ROAD, MATUNGA,
BOMBAY 400 019,
January 10, 1985.

9. SPOTTING OF HABSHI FLAMINGOS IN NANI-BANNI

About 25 kilometres from Bhuj, on both sides of the Road going to Khavda, rain water had accumulated in considerable quantity. This temporary water logging is because of heavy showers in the second week of September, 1984. The water logged area which forms a part of Nani-Banni and has now become a temporary dwelling ground for the migratory birds.

This is my third consecutive monsoon in Kachchh but it is the first time I have seen water and the bird life in this particular area. The previous two have been low rainfall years and not a trace of water was to be seen in this tract of Nani-Banni immediately after monsoon. It appears that the water accumulated during the current year may remain till the end of January, 1985 and I therefore thought it wise to take observations at least twice in a month. This was all the more necessary for me as flamingos form one of the largest populations here and I being one of the members of the Committee appointed by the Government to find out the reasons for their disappearance, was interested in locating the youn gones, if any, as the area is adjacent to the Great Rann of Kachchh.

On 09-10-1984 when the first visit was made to this area the count of flamingos was about 1500. Two small groups of demoiselle cranes and numerous Blackwinged stilts and sandpipers along with coots and few Avocets were located. Careful observation on the flamingos did not reveal the presence of chicks. Whatever small birds were seen could be safely classed as Lesser flamingos because of their adult like movements. While we were making the observations two individuals quite close to the road were seen treading in the water. Because of their dirty white or somewhat blackish-grey colour they attracted my attention. These two individuals behaved exactly like other adult flamingos. One was fully grown while the other was of a slightly smaller size. It had black beak and black legs with dirty white or ashy appearance. The colour was uniformly ash to blackish depending upon the angle of sun's rays. Attempts were made to take a closer look but the birds got disturbed and flew away.

In order to locate these abnormal, blackish-grey flamingos again a visit was made on 20-10-1984 but such birds could not be located. During this visit however the population of flamingos was estimated as over 2000 and number of cranes, coots, stilts and avocets had increased. Dabchiks and cotton teals were spotted during this visit. Osprey and Marsh Harrier were also seen near the pools. A further visit to this area was made on 29-11-1984 and to my great surprise a very high number of blackish grey flamingos were located.

When the count was taken in a group of exactly 400 birds, 21 turned out to be blackish grey. These birds were exactly the size of greater flamingos with the normal variations in size as is seen in the latter. They were so intimately mixed-up with others that they could hardly be separated from the group by a layman.

Because of the above encouraging findings further search was made and to our astonishment an altogether separate group of 16 birds was located at one spot. This was a group of grey or blackish-grey flamingos with blackish beaks and legs. Except for the difference in coloration no other difference could be seen as compared to greater flamingo. These birds had no trace of pink coloration. When observed in flight through binoculars a few blackish individuals could be seen prominently. When these birds were shown to the local inhabitants who have been seeing flamingos all these years they expressed surprise and said that they were seeing such black or "Habshi Flamingos" for the first time.

On going through some of the available literature on flamingos I find that there is no mention of such a blackish-grey flamingo except for some abnormally large sized individuals which will be very few and rare. Here in Nani-Banni area it is seen that every large group has a few such individuals which are not abnormally big but are of varying sizes as is the case in greater flamingos.

I do not know whether any such spottings of blackish-grey or "Habshi Flamingos" is in your records. I would appreciate if I am enlightened about it and if such spottings are not recorded in past then the same may be brought to the notice of the members of the Society through your esteemed *Journal*.

A. A. VAIDYA

CONSERVATOR OF FORESTS,
KACHCHH CIRCLE,
BHUJ,
January 4, 1985.

[I think the dark birds referred to are undoubtedly juveniles in various stages of the brown juv. plumage. In size some brown individuals may be nearly as big as adults. — Sálim Ali]

10. RED SPURFOWL (*GALLOPERDIX SPADICEA CAURINA*)

On 29th May, 1982 I witnessed on interesting behaviour of spur Fowl. In Bhomat, a hilly tract west of Udaipur there is a place called Kiary covered by dry-deciduous miscellaneous forest. I entered a narrow ravine strewn with boulders and scrub jungle looking for Grey Junglefowl (*Gallus sonneratii*). When negotiating a bend I startled a family of spurfowl in front of me, near a fair sized boulder.

The cock started circling the boulder chuckling and gave a spectacular display of its feathers while the hen with her five chicks started climbing the steep slope to my left taking advantage of every bit of cover. The chicks were very small and the side of the ravine was very steep so the progress of the hen was very slow. I changed my direction and edged forward so as to reduce the distance between me and the boulder as well as the hen. The cock increased its pace. It circled the boulder thirteen times and on its last two rounds it passed within a few feet of me. Meanwhile the hen and chicks reached a dense patch of scrub and were hidden from my view. The cock when it was on the other side of the boulder flew away and joined its family.

To save its progeny the cock had diverted the attention of the intruder by madly, circling round the boulder while the hen led the chicks to safety.

In these birds devotion of the cock towards its offspring is very great and it takes considerable risk to protect them.

41, Panchwati,
Udaipur - 313 001,
February 21, 1985.

RAZA H. TEHSIN

11. BREEDING OF THE PAINTED SNIPE (*ROSTRATULA BENGHALENSIS*) IN TRIVANDRUM, KERALA

Since the days of H. S. Ferguson (vide *JBNHS 38*: 694-5 & *39*: 576), no one seems to have recorded the breeding of the Painted Snipe from Kerala. We would, therefore, like to place it on record that we came across a pair of Painted Snipe with a tiny chick in paddy fields near Peroorkada, Trivandrum.

We first saw the Painted Snipe at this place at 1700 hrs on April 23, 1984. Two adults were feeding in a water-logged paddy field. On the 17th of May, 1984, at 1730 hrs we found a male and a female in a field. A few yards away were another male and a tiny chick. While the adult was wading through the slush, the chick swam after it. On seeing us approaching, the parent and the chick hid themselves among the stubbles. When we went closer, the adult flew off and alighted a few yards away. It then put on a 'wounded-bird display', crawling along with one wing raised and the other trailing on the ground. Meanwhile the chick remained silent and motionless. We carried the chick home, took some photographs and within twenty minutes returned the chick to the place where we had found it. We waited at a distance to see what would happen and were greatly relieved to find the parent (the male) coming to the place where the chick was.

We are greatly obliged to Professor K. K. Neelakantan for his help in identifying the bird and for advising us to send this note to the *Journal*.

"Padmalayam", Indira Nagar,
Peroorkada, Trivandrum 695 005,
February 27, 1985.

C. SUSANTH
C. SURESH
S. RAJEEVAN

12. RECOVERY OF A RINGED SANDWICH TERN, *STERNA SANDVICENSIS SANDVICENSIS* FROM RAMESWARAM ISLAND, TAMILNADU

Terns are known for their long intercontinental wintering migration. Though the sandwich tern *Sterna s. sandvicensis* Latham has been known to frequent Sind and Makran coast (Ali and Ripley 1981) and Sri Lanka coast (Ceylon Bird Club Newsletter 1978), it has not so far been recovered from the mainland of India. However it has been sight recorded from Saurashtra (Dharmakumarsinhji 1958).

On 17.9.1983 a sandwich tern was recovered from Kundukal point of Rameswaram Island with a metal ring having Russian inscription and a number P. 702628 on it. The salient characters of the bird are as follows: Crown black, a black stripe continues from the eye back to the crown; body ash colour dorsally, white ventrally; bill long, slender tipped with yellow; legs, web foot and the primaries black. The bird is locally known as 'Katrenji' in Tamil.

It may be mentioned that two other birds of the species were also recovered from the Pillaimadam lagoon, near Mandapam on 24.6.1983 and 7.11.83, indicating that the bird is a common visitor to these areas. They were found along with other common terns, namely *Hydroprogne caspia* (Caspian tern), *Sterna aurantia* and *Gelochelidon nilotica.*

It is of interest that the bird is found in Rameswaram area from 24.6.1983 as indicated by its capture. It is much earlier than its occurrence in the Sri Lanka coast in December. It is not known how much time these birds stay in their wintering areas.

This recovery, the second of the sandwich tern with a ring, confirms that the species is a common migratory bird to the Southern Peninsula.

R. S. LAL MOHAN

Regional Centre of Central
Marine Fisheries,
Research Institute,
Mandapam Camp, Tamil Nadu,
August 18, 1986.

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13. LACK OF TRAFFIC SENSE AMONGST INDIAN ROLLERS

On 28th November 1984, we were travelling on the Bombay-Goa Road. Halfway between Vadakhal Naka and Mahad, our car passed over an Indian Roller (*Coracias benghalensis*) sitting on the middle of the road. I immediately asked the driver to halt, and walked back to the spot where the roller was still sitting on the road.

Whilst I was walking back, five heavy trucks, one Matador van and two cars either passed over the bird or swerved to the side to avoid hitting it. Only once did the bird attempt to fly off, but only succeeded in hitting the bottom of a truck as it passed overhead, and again fell back on the road.

On reaching the roller, I discovered it was an immature bird. Finding that it was still alive, I picked it up. Thinking that it may be critically injured, I placed it on the fork of a large tree on the side of the road. However, to my great surprise, as soon as I released my grip on the bird, it immediately flew off, totally unhurt, and apparently none the worse for its experience.

While returning to the car I noticed a black-winged kite (*Elanus caeruleus*) that had been sitting on an adjacent tree fly away in a different direction. I am unable to say whether the roller had sought the dubious sanctuary offered by the road to escape the unwelcome attentions of the kite, or whether the kite had spotted the roller's hapless plight and had come to capitalise on the situation, or whether the kite's presence was merely coincidental.

DEBI GOENKA

13, Neel Tarang,
210 Veer Savarkar Marg,
Mahim, Bombay-400 016,
December 25, 1984.

14. OCCURRENCE OF THE LITTLE PIED FLYCATCHER (*MUSCICAPA WESTERMANNI*) IN NARSAPUR, MEDAK DISTRICT, ANDHRA PRADESH

On 11th November 1984, the Birdwatchers' Society of Andhra Pradesh had gone on a field outing to Narsapur Forest area (17°45′ N and 78°17′E) in Medak District of Andhra Pradesh. Narsapur is approximately 60 km North-West of Hyderabad city, at a height of 635 m above sea level. The vegetation of the area is mainly deciduous with *Tectona grandis, Terminalia tomentosa, Terminalia arjuna*, etc., as the main plant species.

While walking along a small stream-bed, (at approx. 1100 hours) trying to locate the whereabouts of a pair of Blackbacked Woodpeckers *Chrysocolaptes festivus* which we had seen a few minutes ago, our attention was drawn towards a small (sparrow —) flycatcher in the canopy of a *Terminalia tomentosa* tree. This little black and white bird was flitting about and actively hunting in the upper storey. The plumage was pied with white underparts, a large white wing-patch and a broad, long, white supercilium. The upper plumage was black in colour and the sides of the tail, near the base were white. We watched this bird for a good ten minutes as it flittered about above us. All identification marks pointed to a male Little Pied Flycatcher *Muscicapa westermanni* !

According to the HANDBOOK, *Muscicapa westermanni* is an "altitudinal and short-range migrant, not common." It is found in North-East India and "winters in the foothills upto *c* 1800 m, and over the plains as far as Surguja (North-East M.P.), Manbhum (South Bihar) and Midnapore (West Bengal)." ... In winter frequents the vicinity of well-wooded streams.

The bird we saw was most likely a wintering vagrant. Altitude does not seem to be an important criterion in its winter range, since it has been already been reported from areas with such diverse heights as 915 m above sea level (Surguja) and sea level, i.e., 0 ft (Midnapore). However the wintering habitat preferred by this bird is represented almost exactly in Narsapur where we saw it in the vicinity of a well-wooded stream.

14-7-370 BEGUM BAZAR,
HYDERABAD 500 012,
December 28, 1984.

AASHEESH PITTIE

REFERENCE

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15. BLYTH'S REED WARBLER *ACROCEPHALUS DUMETORUM* WITH AN ABNORMAL RECTRIX

(*With a text-figure*)

An unusual specimen of Blyth's Reed Warbler *Acrocephalus dumetorum* was caught at Point Calimere, Tamil Nadu on 3 November 1983. On examination it was noted that the right centre rectrix was nearly upside-down (Fig. 1). The feather was firmly attached to the bird and there was no evidence of any damage. The rest of the plumage was normal and in fresh condition, indicating that the bird had recently completed a full moult and this was an adult (Gaston 1976). It was ringed and released. I am aware of only one other instance of a similar abnormality, that of a male Copper Pheasant *Syrmaticus soemmeringi*, reported by Murie (1865).

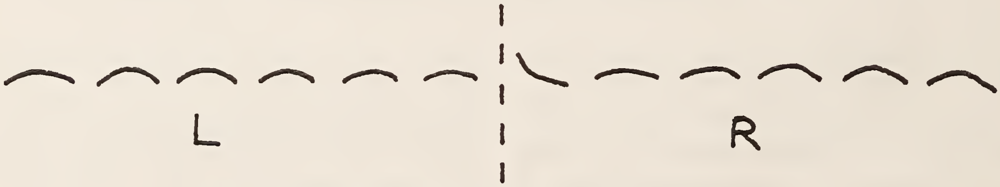

Fig. 1. End-on view of tail of *Acrocephalus dumetorum*.

ACKNOWLEDGEMENTS

I thank Dr. Salim Ali and S. A. Hussain for inviting me to join the BNHS Avifauna Project team and Dr. R. Sugathan for his hospitality and assistance.

BNHS Avifauna Project,
Hornbill House,
Shaheed Bhagat Singh Road,
Bombay 400 023,
February 25, 1985.

DAVID S. MELVILLE[1]

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16. OCCURRENCE OF CROWNED LEAF WARBLER (*PHYLLOSCOPUS OCCIPITALIS*) IN BOMBAY

The Crowned Leaf Warbler (*Phylloscopus occipitalis*) winters in the peninsula from Southern Gujarat, Madhya Pradesh and Eastern ghats, south to southernmost hills (Ripley 1982). This species is not included in the 'Birds of Bombay and Salsette' (Ali & Abdulali 1941) and in the recent, 'Checklist of birds of Borivli National Park'. (Abdulali 1981).

I first came across this species in Borivli National Park in January 1984 and in the winter seasons of 1983-84 and 1984-85, I was able to get more than 10 sightings of this species in the Park. It seems that this species is not an uncommon visitor to Borivli National Park. I also saw a small flock of this species in Karnala Bird Sanctuary on 2nd February 1985. In the National Park this species seems to prefer denser parts of forest with tangled vegetation with creepers etc. It is always found in small flocks, mostly in hunting parties with fly-catchers, bulbuls etc., and is silent.

This phylloscopus is one of the easiest to identify in the field. The prominent coronal bands distinguish it at once from other phylloscopus species that winter in this area. (Except from *P. reguloides* which do not occur here.) The yellow wingbar, yellow wing-bend and the pinkish bill are also prominent. The undertail coverts are creamish in colour and have curious plumpish appearance. I am familiar with this species in the W. Himalayas, where I was able to spend two summer seasons (1983 and 1984) watching the *Phylloscopus* genus. It is also interesting to note that there is marked change in the colour of the bill in breeding and non-breeding season. The bright orange lower mandible in summer changes to dull pinkish in winter, and possibly plays an important role in the breeding biology of this species.

3, Rocky Hill,
Malabar Hill, Bombay 400 006,
February 6, 1985.

NITIN JAMDAR

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17. NEW RECORDS OF SOME BIRDS FROM DIFFERENT PARTS OF EASTERN INDIA

During faunistic surveys conducted by me in different parts of eastern India since 1977, I came across some birds which appear to be new records from those areas. They are:

1. The Himalayan Cuckoo, *Cuculus saturatus saturatus* Blyth

As per extant literature the Himalayan Cuckoo winters in the plains of Uttar Pradesh, Rajasthan, Bihar and Assam. However, I collected a male at Baj Baj, 24 Parganas district, West Bengal, on 23 October 1977. The presence of a few feathers with brown bars on the chin and upper breast and an ashy spot on the crown indicate that it is a young bird.

Material: 1♂ (23 Oct. 1977), Baj Baj, 24 Parganas, West Bengal; Srikumar Chattopadhyay, collector.

Measurement (in mm): Wing 193, tail 163, bill 97.

The species can be identified in the field by its smaller size than the Asiatic Cuckoo, *Cuculus canorus*, and the pure white edge of shoulder which is clearly visible when the bird is perched. After this collection I have observed this bird on two more occasions. Once on 7 October 1981 on the eastern side of the Dhakuria Lake in Calcutta, the bird was in hepatic phase and was being chased by crows; and again on 14 October 1984 in the Senpukur Swamp at Baj Baj. On the last occasion there were two birds foraging for rice moths in a patch of *Scirpus* sp. in an inundated paddy field. On both the occasions the birds were completely silent. It is also to be noted that these birds were seen only during October in lower Bengal and all attempts to locate them after October failed, which may indicate that they were on passage.

2. Mandelli's Yellowbrowed Leaf Warbler, *Phylloscopus inornatus mandellii* (Baker)

Out of the three subspecies of the Yellowbrowed Leaf Warbler, *Phylloscopus inornatus*, two are reported from lower Bengal, *viz.*, Hume's Yellowbrowed Leaf Warbler, *Phylloscopus inornatus humei* (Brooks) and the Siberian Yellowbrowed Leaf Warbler, *Phylloscopus inornatus inornatus* (Blyth). During a bird collection trip around Baj Baj in Lower Bengal, I collected an example of Mandelli's Yellowbrowed Leaf Warbler on 26 October 1977. It was collected from the first storey of an old mango tree, while foraging and producing a feeble, long-drawn, sweet *si-i-ip*. This bird has a very prominent supercilium which is pale yellow in the proximal part up to the eye and whitish distally. Two prominent wing bars are nearly white, and the outer edges of scapulars are white with faint greenish wash. Upper parts darker and rump bright green, which confirms its identity. Another specimen was collected on 14 December 1978, from an identical habitat in a neighbouring village. This is a new record of this bird from lower Bengal.

Material: 1♂, 1♀ (14 Dec. 1978, 26 Oct. 1977), Vill. Barabagan and Vill. Senpukur, Baj Baj, 24 Parganas District, West Bengal; Srikumar Chattopadhyay, collector.

Measurements (in mm):

	Wing	tail	Bill
♂	58	42	12.5
♀	53	40	10.5

It is also to be noted that both the specimens have very narrow white edges on sixth to 10th primaries, all secondaries and tertiaries.

3. The Himalayan Rubythroat, *Erithacus pectoralis* (Gould)

During November 1979, I visited an island locally known as Sahebdubir Chaur, *c* 5 km south of Sagar Island, 24 Parganas District, West Bengal. The island which is used as a temporary fishing centre by local fishermen, is mostly barren with small sand-dunes barring some grasses, *Ipomoea* species and a few stunted mangrove bushes.

The island attracts a large number of birds, mainly gulls, terns and waders, and the stunted mangrove bushes attract a large number of passerines. Among other birds, I have collected an example of the Himalayan Rubythroat from one such bush. The specimen was a female with dark grey breast, tail tip white suffused with rufous; underwing grey, inner side of the thighs grey and brown on the outer side.

Material: 1♀ (11 Nov. 1979), Sahebdubir Chaur, off Sagar Island, 24 Parganas district, West Bengal; Srikumar Chattopadhyay collector.

Measurements (in mm): Wing 70, tail 56, tarsus 29, bill 15.

The specimen had nonbreeding ovary.

4. Redwinged Crested Cuckoo, *Clamator coromandus* (Linnaeus)

While bird watching in the western slope of Susunia Hill, *c*. 11 km north of Bankura town, West Bengal, in the afternoon of 18 August 1984, I heard a call, vaguely reminiscent of the call of the Green Magpie, *Cissa chinensis*, from the other side of the hill. As I approached towards the source, I inadvertently disturbed a group of the Common Langur foraging on the top of the hill, and the langurs rushed down the other side of the hill and probably disturbed the bird which came flying overhead, calling and alighted in the Sal and Teak forest at the base of the hill. In flight it resembled the Pied Crested Cuckoo, but had very dark chestnut wing and a white collar, which confirmed its identity as the Redwinged Crested Cuckoo, *Clamator coromandus* Linnaeus.

The bird was observed again in a patch of Sal and Teak on the western side of the hill on the next day in the morning. The bird was very silent and therefore difficult to locate when perched. It gives its *klinck-klinck* call in rapid succession in flight, and also when disturbed at rest.

According to the extant literature, this bird breeds in the Himalayan foothills from Garhwal east to Arunachal Pradesh and south in the hills of Assam and the adjoining states. The bird seen by me in Susunia Hill was probably on passage to South India.

ACKNOWLEDGEMENT

I am grateful to Dr. B. Biswas for his kind help and constant inspiration in this study.

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18. A NOTE ON A HAWKSBILL TURTLE (*ERETMOCHELYS IMBRICATA*) AT GAHIRMATHA BEACH OF BHITARKANIKA WILDLIFE SANCTUARY, ORISSA

Gahirmatha beach, a stretch of 35 Km. long in Bhitarkanika Wildlife Sanctuary of Orissa is renowned for mass nesting or 'arribada' of Olive Ridley Turtles, *Lepidochelys olivacea.* No other species of marine turtles, except Olive Ridley turtles have been observed nesting at Gahirmatha beach. However, in March, 1984 one adult dead leatherback turtle (*Dermochelys coriacea*) was recovered from Shortt's Island, not far from Gahirmatha turtle nesting beach which was in an advanced stage of decomposition. Again, in the night of 20.2.86 a sub-adult Hawksbill turtle (*Eretmochelys imbricata*) was seen crawling on the beach by the Research Assistant and the Research helpers, who were actively collecting data on mass emergence, nest and nesting of olive ridley turtles. It was captured and was brought to the Gahirmatha Marine Turtle Research and Conservation Centre and retained in captivity for study on its food and feeding, growth and behavioural aspects. Nesting of Hawksbill turtle in Orissa coast has so far not been observed/reported. Sporadic nesting of Hawksbill turtles along the Tirunelveli coast of Tamilnadu has been reported by Fernando (1983).

This Hawksbill turtle is now doing well at the centre and has increased its weight of 5.5 Kg. and length of 0.5 m. (at the time of capture) to 7.2 Kg. and 0.62 m. respectively (15.9.86).

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Reference

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19. CANNIBALISTIC BEHAVIOUR OF FRESH WATER TURTLES IN KEOLADEO NATIONAL PARK, BHARATPUR, RAJASTHAN

The Keoladeo National Park at Bharatpur has an aquatic area of 8.5 sq. km. During the summer of 1985 the aquatic area dried up completely leaving a deep pond, Manasarovar where the water was between 40-50 cm. A massive concentration of about 358 turtles were noticed in this pond. Most of them were *Lissemys punctata.* The turtles very active between 02.00 and 05.00 hrs, and 18.00 and 20.00 hrs.

On 2nd July 1985 at 07.00 hrs, I saw in the water a big turtle catching by the neck a small turtle of the same species. The small turtle struggled for about ten minutes to escape; but it was futile. The upside down body of the small turtle was dragged above the water level and the plastron could be seen above the water. The dead, turtle was carried along the pond slightly above the water level. Almost a similar incident was noticed on 5th July also.

On the morning of 6th July, I saw a dead turtle in the shallow water on the shoreline of the same pond. The fore and the hind limbs on the left side of the body were completely eaten. When I pushed the carcass slowly into the deeper water 3-4 small turtles of the same species appeared all of a sudden and started feeding on the dead turtle. A big turtle came about 5 minutes later and carried away the dead turtle by holding it upside down above the water level. Another big turtle was attracted to this and there was a tussle between the two for the carcass.

There is no previous record of cannibalistic behaviour of fresh water turtles from the Park.

One of the possible reasons for this cannibalistic behaviour could be the tough competition for space as there was no other water body in the park during this period. Whether it was for food is not clear as Daniel (1983) has recorded that the turtle could survive without food for 2 years.

ACKNOWLEDGEMENTS

I am thankful to Dr. V. S. Vijayan, Project Scientist for encouraging me to write this note.

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REFERENCE

DANIEL, J. C. (1983): The book of Indian Reptiles. Bombay Natural History Society, Bombay. pp. 141.

20. FRESH WATER TURTLE CAPTURING AQUATIC BIRDS

On the morning of 1st October 1985, I saw a fresh water turtle capturing a cormorant in an *Ipomoea* patch of the Keoladeo National Park, Bharatpur. This observation was made near the sluice gate in Sapan mori area, where a large flock of cormorants were actively feeding on fish. Suddenly quite close to the road, a turtle grabbed the leg of one of the little cormorants. The bird flapped its wings and struggled to escape for more than 5 minutes, when at the approach of a tourist, the turtle left the bird and disappeared. It had crushed the leg of the bird upto the thigh. Within an hour I observed similar incidents but this time the species were the shag and large cormorant. These are not uncommon incidents in the Park as I have recorded turtles capturing Indian moorhen, bronzewinged jacana, gadwall, little grebe, coot and cotton teal. I am not sure whether the turtle feed on these birds or not. The fresh water turtle capturing coot has been reported earlier by Kannan (1985). But their observations on other species has not been reported earlier from this Park.

ACKNOWLEDGEMENTS

I thank Dr. V. S. Vijayan, Project Scientist and Dr. (Mrs.) Lalitha Vijayan, Senior Field Biologist, BNHS Ecological Research Centre, for their encouragement.

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REFERENCE

KANNAN, R. (1985): Fresh water turtle capturing coot. *J. Bombay nat. Hist. Soc. 82*(1): 244.

21. RECORD OF THE FUNGOID FROG *RANA MALABARICA* (BIBRON) IN NAVSARI (GUJARAT STATE)

A frog was collected from a temporary flooded area at Navsari and was identified as *Rana malabarica* (Bibron) on the basis of colour and other characters.

This frog appears to be rare in this area. So far it could be located only at Navsari, a town in South Gujarat.

The earlier records regarding its distribution indicates its occurrence in Western ghats and low lands along west side of ghats from Kasara Ghat in Nasik district of Maharashtra to Edanad, Chenganur (Kerala). (J. C. Daniel 1975).

The occurrence of *Rana malabarica* (Bibron) in Gujarat is being reported for the first time with our finding a specimen of this species at Navsari.

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REFERENCE

DANIEL, J. C. (1975): Field guide to the amphibians of Western India. Part III. ibid. *72*(2): 506-522.

22. OCCURRENCE OF WHIRLING DISEASE IN *CIRRHINA MRIGALA* IN WARDHA

(*With a photograph*)

Information on occurrence of whirling disease in the major carps in India is sparse. During my visits to Fish Seed Farm, Kelzar (District Wardha) in 1983. I collected a few specimens of *Cirrhina mrigala* with deformed spinal column. These were found to be similar in appearance to European and American salmonids suffering from whirling disease as reported in Fish Culture by Marcel Huet. I preserved one of them for the departmental museum.

In August 1984 I brought about 100 fingerlings of mrigal from the same farm for intensive culture for study of their growth rate many of them died by October end. In November 1984 one of the remaining fishes had a similar deformed spine. It had grown to about 10 cm. It was taken out of the culture tank and kept separately in an aquarium for observation. It was observed that the fish used to take rounds in the same direction several times, coming to the surface and then falling to the bottom. It repeated the same process after some time. This went on for two weeks and then it died. The deformed spine and the specific behaviour of the fish was a clear indication of the whirling disease.

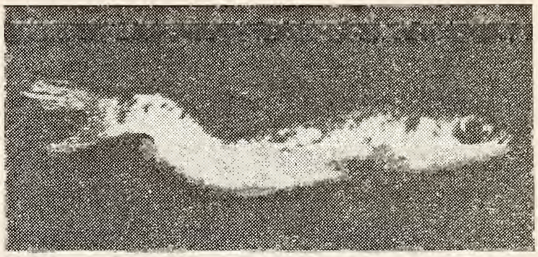

Photo. 1. Mrigal suffering from whirling disease.

I then contacted the Fisheries Development Officer, Kelazar requesting him to give me more information, if he had also come across such deformities in the fishes left and reared in the farm after the sale of seed every year.

In the last week he sent me one Twelve inch specimen of mrigal with similar characteristics. More information is yet to be collected.

If the disease has invaded the farm it could be very harmful, as once a fish is infected by the causative agent, the protozoon *Myxosoma* (*Leptospora*) *cerebralis*, it cannot be cured. And once a farm is infected it is difficult to rid it of the disease.

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23. DEVELOPMENT AND SURVIVAL OF *MYZUS PERSICAE* (SULZER) ON *TARAMIRA* (*ERUCA SATIVA* LINN.) INFLORESCENCE AT LUDHIANA*

INTRODUCTION

Out of ten different species of insects reported to attack *taramira* in Punjab, *Myzus persicae* is the only insect which causes economic damage (Sandhu *et al.* 1981). The insect attacks 33 plant species belonging to 15 different families around Ludhiana (Punjab). In addition to the loss caused by feeding, the insect is capable of transmitting more than one hundred virus diseases in India (Nagaich and Agrawal 1969).

In the early stage of this crop the nymphs and adults of this insect suck cell sap from the leaves, but after the appearance of inflorescence developing buds are preferred. This leads to reduction in the size and number of pods. (Singh and Singh 1985). Since the aphid is confined to the inflorescence after the bud initiation stage, it was considered desirable to study the development and survival of *M. persicae* on inflorescence during the peak activity period, i.e. January-April. The results are presented in this paper.

METHODS AND MATERIAL

The studies were conducted in the screen house cages of the Department of Entomology, Punjab Agricultural University, Ludhiana. Various parameters, *viz.* nymphal instars, nymphal duration, nymphal survival, pre-reproductive, reproductive and post-reproductive periods, fecundity and longevity were studied for two generations. For this study the plants of ITSA variety of *taramira* were grown in earthen pots (14 cm dia.) and raised up to inflorescence stage. A single apterous aphid was released on the inflorescence under a cylindrical alkathene microcage, 15 cm long. In order to fix it on the inflorescence, it was supported with the help of a wooden stick using rubber band. It was closed by muslin sleeves at its ends. Twenty five such plants were kept for the study. The observations were recorded daily.

Observations for one generation were recorded during third week of January to third week of March (over temperature 13.2°C and R. H. 62%) and for second generation from first week of March to second week of April (over temperature 21.1°C & R.H. 56%).

RESULTS AND DISCUSSION

Duration of various nymphal instars: The duration of first instar nymph (Table 1) varied from 2-4 days from third week of January to third week of March. It varied from 2-3 days from first week of March to second week of April. The overall mean duration of 1st instar was 2.4 ± 0.31 days.

The duration of second instar nymph was 2-4 days from third week of January to third week of March. It was only 2 days from first week of March to second week of April. In all the 2nd instar nymph took 2.5 ± 0.54 days.

The duration of third instar nymph varied from 2-5 days from third week of January to third week of March. The duration of this instar was 1-2 days from 1st week of March

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* Based on the thesis of the senior author, approved for M.Sc. (Entomology) degree of Punjab Agricultural University, Ludhiana.

TABLE 1

DURATION AND SURVIVAL OF NYMPHAL STAGE OF *M. persicae* ON INFLORESCENCE

Period of observation		Mean duration of nymphal instars (days)				Total nymphal period (days)	Nymphal survival (%)	Tem. (°C)	R.H. (%)
		Ist	IInd	IIIrd	IVth				
Jan.-March (23.1.83 to 21.3.83)	Range	2-4 days	2-4 days	2–5 days	2–8 days	13–19	64	13.2	62
	Mean	2.71±0.54	3.09±0.60	4.55±0.92	5.15±1.26	15.68±1.77			
March-April (4.3.83 to 13.4.83)	Range	2–3	2	1–2	2–3	8–9	73	21.1	56
	Mean	2.09±0.28	2.0 ±0.0	1.81±0.38	2.18±0.38	8.09±0.28			
Overall Mean±S.D.		2.4 ±0.31	2.54±0.54	3.18±1.37	3.66±1.48	11.88±3.79			

TABLE 2

PRE-REPRODUCTIVE, REPRODUCTIVE, POST-REPRODUCTIVE PERIOD, LONGEVITY, PERIOD OF GENERATION AND FECUNDITY OF *M. persicae* ON INFLORESCENCE

Period of observation		Pre-reproductive period (days)	Reproductive period (days)	Post-reproductive period (days)	Adult longevity (days)	Period of generation (days)	Minimum fecundity	Maximum fecundity	Average fecundity per generation
Jan.-March (23.1.83 to 21.3.83)	Range	1–3	3–32	0–9	3–39	21–56	3	89	37.1
	Mean	1.88±0.58	16.18±8.21	1.75±2.56	17.93±10.37	36.18±9.97			
March to April (4.3.83 to 13.4.83)	Range	0–1	5–21	0–23	5–42	13–50	22	87	69.4
	Mean	0.54±0.49	18.4±4.30	16.36±6.24	34.36±9.98	40.27±12.08			
Overall mean±S.D.		1.21±0.67	17.09±0.91	9.05±7.30	26.14±8.21	38.22±2.04			

to second week of April. The overall mean duration of this instar was 3.18 ± 1.37 days.

The duration of fourth instar nymph varied from 2-8 days from third week of January to third week of March, and 2-3 days from 1st week of March to second week of April. On an average, the fourth instar nymph was completed in 3.66 ± 1.48 days.

Total duration of nymphal instars: The nymphal stage lasted for 13-19 days from third week of January to third week of March. The total nymphal period varied from 8-9 days from first week of March to second week of April. The overall mean duration of nymphal instars was 11.88 ± 3.79 days (Table 1).

Survival: The survival of nymphs varied from 64 per cent during January-March to 73 per cent during March-April.

Pre-reproductive period: The pre-reproductive period varied from 1-3 days from third week of January to third week of March but it varied from 0-1 days from 1st week of March to second week of April. In all, pre-reproductive period was completed in 1.21 ± 0.67 days on inflorescence (Table 2).

Reproductive period: The duration of reproductive period varied from 3-32 days from third week of January to third week of March. From 1st week of March to second week of April, the reproductive period varied from 5-21 days. The mean reproductive period of this aphid was 17.09 ± 0.91 days (Table 2).

Post-reproductive period: The post-reproductive period varied from 0-9 days from third week of January to third week of March and 0-23 days from first week of March to second week of April (Table 2). On an average, the post-reproductive period of this aphid on inflorescence lasted for 9.05 ± 7.30 days.

Adult longevity: Mean longevity of adult was 26.14 ± 8.21 days.

Period of generation: It ranged from 21-56 days from third week of January to third week of March and 13-50 days from first week of March to second week of April. The average longevity of this aphid was 38.22 ± 2.04 days (Table 2).

Fecundity: The number of young ones laid by a single female varied from 3-89 from third week of January to third week of March and 22-87 from first week of March to second week of April (Table 2). Average fecundity per generation in former case was 37.1 nymphs, whereas in latter case it was 69.4 nymphs.

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SINGH, G. & SINGH, G. (1985): Effect of dates of sowing on the appearance and abundance of *Myzus persicae* (Sulzer) and yield of *taramira* crop. *Indian J. agric. Sci. 55*(4): 287-289.

24. MORMON BUTTERFLY (*PAPILIO POLYMNESTER*) AND ITS STATUS AROUND BOMBAY

I refer to Mr. J. S. Serrao's note under this heading (1978, JBNHS 75: 241), I wish to present my observations on this butterfly in Bombay.

I have seen this butterfly between August and September every year since 1978 (1978, 3 sightings; 1979, 4 sightings; 1980, 5 sightings; 1981, 4 sightings) in IIT Powai. In 1982 this butterfly seemed to be fairly common throughout from July to March and it was also reported by several of my colleagues. In all these sightings the butterfly did not seem to be flying in any particular direction.

It has also been observed several times in Borivli National Park, around Tulsi lake dam during monsoon months. On August 6th 1979, one specimen was seen flying near Matunga station at 10.00 hrs. It was flying towards west and settled on Lantana flowers for few seconds.

Several other observers also have seen this butterfly on different occasions in and around Bombay (Tungareshwar and Chinchoti Waterfalls). These observations show that this butterfly is probably a seasonal migrant and have become more abundant in recent years or must have escaped the observation of competent observers in the past.

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25. OCCURRENCE OF *CYDIA* SP. ? *FUNEBRANA* (TREITSCHKE) AS APRICOT FRUIT BORER — A NEW RECORD FROM INDIA

In the year 1978-79, heavy infestation by a lepidopteran fruit borer was observed on apricot at several localities of Himachal Pradesh stretching from 1500 to 2100 m above mean sea level. Its incidence was 20 (Janjehli area of Mandi district) to 100 per cent (Chopal area of Simla district). In the following two years, its attack remained low and detailed investigations on the biology, behaviour and control of this pest were made during 1981 to 1984 at Janjehli (2100 m) where the pest had more preference to apricots than to plums.

For obtaining the adult moth, infested fruit were brought to the laboratory and kept in jars containing seived sand. The moths were identified by the Commonwealth Institute of Entomology London as *Cyd*ia sp.? *funebrana* (Treitschke), of the family Tortricidae of order Lepidoptera.

The moths were seen on wing at dusk from April end to May. Usually, eggs were laid singly on developing fruit at dusk. Female had a capacity to lay 40 to 60 eggs which hatched in 9 to 14 days. The neonate larva crawled over the fruit before boring into it from any point. Depending upon stage of the fruit development, 1 to 7 larvae per fruit were observed. The caterpillar made galleries of variable shape and size by feeding on mesocarp, preferably around the stone. Sometimes, the larva superficially gnawed the developing stone. Presence of the caterpillar and its excreta, as well as development of sooty moulds on the deteriorating fruit render it unfit for human consumption. The attack could easily be detected by the presence of a brownish ring around the minute entrance hole from which juicy secretion oozes out. Such infested fruit often fell down at slight disturbance. The falling of infested fruit synchronized with the physiological fruit-drop in June and hence the pest attracts little attention from the orchardist. Full grown larvae come out of the fruit in 21 to 24 days and form cocoon near the base of the tree, on its bark or any other suitable site on the ground and pupate inside. Moths emerged from pupae in first week of June to the June-end and lived for a week or so (8 to 10 days). Eggs laid by the impregnated females hatched in 8 to 10 days. Developing larvae of the second generation were found in the ripened fruit. Such infested fruit usually dropped down and larvae continued to feed on the pulp. Under the climatic conditions of Janjehli, almost completely developed larvae were observed in such fallen rotting fruit until end of August. Since some full fed larvae were observed hiding under the silken web in cracks and crevices of the bark, such larvae were periodically observed *in situ.* They pupated by the mid of April and moths emerged by the April end to first week of May. Thus the pest overwintered as full-fed larvae and had two generations in a year.

Collection and destruction of fallen fruit and debris harbouring cocooned larvae, and treatment of tree-basins with 200-250 g aldrin 5%, or BHC 10% dust by end of August, reduced the inoculum and incidence of the pest in the ensuing year. Further, it was noticed that in orchards where dormant spray oil (Hindustan Petroleum Spray Oil E) 2% mixed with fenitrothion. 0.05% was sprayed, a negligible attack of the pest was noticed in the following season. In preliminary field trials, spraying of fenitrothion 0.05%, quinalphos 0.05%, malathion 0.1%, or carbaryl 0.2% in first week of May followed by a second spray by first fortnight of June provided effective control of the pest on apricot.

Cydia funebrana is a well known pest the world-over of the plum and is known to occur in France, Italy, Central Europe, Scandinavia, North-Western and South-Western Russia and Asia Minor (Vassiliev 1913). On apricot fruit, *Anarsia lineatella* Zell. has been recorded in Kashmir (Fletcher 1932) and *Cacoecia sarcostega* Meyr. damaged fruit in Baluchistan (Pruthi 1938). Atleast from India, occurrence of *Cydia* sp.? *funebrana* on apricot is a new report. Life history and behaviour of this species resembles with that recorded from Switzerland (Faes *et al.* 1934, Bovey 1936), and Austria (Böhm 1948).

ACKNOWLEDGEMENTS

We are grateful to Dr. J. D. Bradley and Dr. D. J. Carter of Commonwealth Institute of Entomology, London, for identification of the apricot fruit tortricid.

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VASSILIEV, EUG. M. (1913): The latest data concerning caterpillars which injure the principal fruit crops in Russia and Western Europe. Reprint from (*Horticulturist* and *Market Gardenar*) *Kiev*, nos. 46-47, 12 pp.

26. MULBERRY, *MORUS ALBA* LINNAEUS, A NEW HOST PLANT FOR THE BLUE PUMPKIN BEETLE, *RHAPHIDOPALPA INTERMEDIA* JACOBY (CHRYSOMELIDAE: COLEOPTERA)

Mulberry (*Morus alba* L.) has been reported as host for four leaf beetles, *Chirida bipunctata* Linnaeus, *Cryptocephalus schestedti* Fabricius, *Aspidomorpha miliaris* Fabricius and *Rhaphidopalpa abdominalis* (Fabricius) (Chrysomelidae: Coleoptera), which feed on the leaf of the mulberry (Kotikal 1982).

Studies conducted at Agricultural College campus, University of Agricultural Sciences, Dharwad on various insect pests of mulberry revealed the occurrence of the blue pumpkin beetle, *Rhaphidopalpa intermedia* Jacoby on mulberry during the months of September-October, 1984. The beetles fed on the leaves and flowers of all three cultivated varieties of mulberry, i.e. Mysore local, M-5 and S-54. The beetles were mostly found on the tender leaves and damaged them by making small holes. The average population of adults per plant was two.

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REFERENCE

KOTIKAL, Y. K. (1982): M.Sc. (Agri.), thesis submitted to the University of Agricultural Sciences, Bangalore.

27. *CAREX HEBECARPA* MEY. — A NEW RECORD FOR NORTH-WEST HIMALAYA

While studying the specimens of the genus *Carex* L. in the herbarium of Forest Research Institute, Dehradun (DD) for the 'Flora India Project', a specimen collected from Himachal Pradesh and labelled as *C. foliosa* was found to be different. On critical examination and matching it with type and authentic specimens, it was identified as *C. hebecarpa,* not known from N.W. Himalaya, earlier. *C. foliosa* and *C. hebecarpa* are representatives of two different subgenera of *Carex.* The main differences are in the nature of style and inflorescence. In *C. foliosa* the style is 2 fid and inflorescence is spicate while in *C. hebecarpa* the style is 3 fid and inflorescence is clearly racemose type.

The up to date nomenclature of *C. hebecarpa* alongwith flowering and fruiting period, distribution, ecology and specimens examined is as follows:-

Carex hebecarpa Mey. in Mem. Acad. St. Petrsb. 1: 223, t. 12. 1831; Clarke in Hook. f. Fl. Brit. Ind. 6: 747. 1894 excl. syn. *C. lachnosperma* Kuekenth. in Engl., Pflanzenr. *heft* 38: 744. 1909; Koyama in Hara *et al.*, Enum. Fl. Pl. Nepal. 1: 102. 1978, Rao *et* Verma Cyper. N.E. Ind. 85. f. 62-62 b. 1982. *C. kunthii* Drejer, Symb. Caric. 22. 1844.

Fls. and Frts.: March-Sept.

Distribution: INDIA: Arunachal Pradesh, Assam, Himachal Pradesh, Manipur. INDO CHINA, NEPAL.

Specimens examined: Himachal Pradesh, Shille, 4,850 ft. (1,478 m), 23.9.1950, *Range officer* 50 (DD).

I am thankful to Dr. U. C. Bhattacharyya, Deputy Director, Central National Herbarium Howrah for encouragement. Thanks are also due to Shri B. M. Wadhwa, Regional Botanist at Kew for sending the photographs of type and authentic specimens.

BOTANICAL SURVEY OF INDIA,
NORTHERN CIRCLE,
DEHRA DUN 248 001,
August 17, 1985.

NEELAM GHILDYAL

28. VEGETATION OF THE KAPILAS HILLS IN DHENKANAL DISTRICT, ORISSA

INTRODUCTION

The Kapilas, a short range of hills is located in the district of Dhenkanal which lies between 20°29′ and 21°42′ N latitudes and 84°16′ and 86°2′E longitude. The term "Kapilas" might have been derived from "Kailas", the abode of Lord Siva, now called as Chandrasekhar. The temple is situated on the slope of the peak at a height of 1500 ft. A zigzag motorcycle path leads upto the temple front from Deogan which is 15 miles east of Dhenkanal. Kapilas is regarded as a summer resort of Orissa. This has also been declared as a Wildlife Sanctuary by the Govt. of Orissa (vide Notification No. 1443 dt. 22.6.83). Principal animals of the sanctuary are Panther, Spotted Deer, Wild Boar etc. The main objective of this sanctuary is to protect the forest ecosystem and hill ranges alongwith the typical life-forms.

There are numerous peaks in the Kapilas hill range, the loftiest being 2280 ft. at Devasava. There is also a spring which has attained religious sanctity. The climate is moderately salubrious with temperatures not exceeding 35°C in Summer and not less than 13°C in Winter. The average rainfall is 55 inches. Soil is mostly lateritic.

BOTANICAL WORK: PAST AND PRESENT

Haines (1961) while botanising in Bihar and Orissa reported 227 species of Angiosperms from Dhenkanal district. However, he reported only 6 taxa from the Kapilas hills though it is floristically very rich. It seems, he had visited Kapilas only once during his survey. Mooney (1950) who concentrated on the hilly tracts of Western Orissa had not collected in the Kapilas hills. Thereafter, records reveal that very few collections have been made. In the Orissa District Gazetteer on Dhenkanal (Senapati & Tripathy 1972) there is scanty information regarding the vegetation of the district as a whole. Realising the meagerness of floristic information we undertook a detailed floristic survey of this region under the District Flora Scheme sponsored by Botanical Survey of India. Through regular field trips, plants were collected in different seasons. Phenology, sociability, ecological aspects we studied with critical observations on vegetational pattern.

Vegetation:

The vegetation mainly falls under Tropical Semi-evergreen mixed type of forest. The top canopy is mostly composed of large deciduous/evergreen trees like *Adina cordifolia, Bridelia tomentosa, Mitragyna parviflora, Xylia xylocarpa, Mallotus philippensis, Mangifera indica, Shorea robusta, Callicarpa arborea, Anogeissus latifolia, Artocarpus heterophyllus, Cassia fistula, Ochna obtusata, Kydia calycina, Polyalthia cerasoides, Ardisia solanacea, Macaranga peltata, Dalbergia sissoo, Semecarpus anacardium, Pterospermum heyneanum Protium serratum* etc. Of these *Shorea robusta* is found in pure stands on the hill top. *Caryota urens* is also met with occasionally. The chief climbers associated with the top storey plants are *Schefflera venulosa, Bauhinia vahlii, Calycopteris floribunda, Combretum roxburghii, Acacia pennata, Millettia racemosa* etc. The ground flora is composed of *Flemingia chappar, Clausaena excavata, Flemingia bracteata, Desmodium pulchellum, Murraya koenigii* etc. which are characteristic elements of sal forest. However, during dry season most of them wither away as such the ground becomes barren except for a few hardy and xeric species.

The plants like *Lagerstroemia parviflora, Bixa orellana, Aspidopterys indica, Grewia disperma, Wrightia arborea, Trema orientalis, Wrightia tinctoria, Stereospermum tetragonum* form the second storey. At lower heights on the hill the gregarious growth of plants like *Boehmeria macrophylla, Colebrookea oppositifolia, Micromelum integerrimum, Pavetta tomentosa, Glycosmis arborea, Leea macrophylla* are very conspicuous. Scandent shrubs and twinners like *Opilia amentacea, Celastrus paniculatus, Clematis smilacifolia, Cynoglossum lanceolatum, Ipomoea eriocarpa, Cryptolepis buchananii* are also found in association with these plants. This association forms the micro-ecological niche which provides cogenial habitat for shade-loving plants like *Psychotria adenophylla, P. curviflora, Thysanolaena maxima, Ecbolium viride, Petalidium barlerioides, Phaulopsis imbricata.*

The notable epiphytic taxa are *Dendrophthoe falcata, Viscum nepalense, Vanda tessellata, Bulbophyllum triste* which are mostly found in the higher elevation chiefly growing on *Shorea robusta* and *Mangifera indica.* Ferns like *Drynaria quercifolia, Pyrosia nummularifolia* growing on mango trees are also common. Along the edge of the spring hygrophillous plants are abundant, alongwith some pteridophytic species such as *Doryopteris ludens, Pleopeltis linearis, Adiantum caudatum, Pteris biaurita* and *Adiantum capillus-veneris.*

Succulent herbs like *Rhynchoglossum obliguum, Begonia picta, Epithema carnosum* grow along with *Elatostema cuneatum, Biophytum sensitivum* in abundance on moss-covered rock steps in early Winter.

Terminalia alata, Terminalia bellerica, Shorea robusta, Madhuca longifolia var. *latifolia, Xantolis tomentosa, Azadirachta indica, Aegle marmelos* etc. form a thick belt around the hill base and represent a mixed category mostly associated with *Combretum roxburghii* as a dominant climber. The shrubby elements are poor in respect of variety. However, *Holarrhena antidysenterica, Clerodendrum viscosum, Chromolaena odorata, Cipadessa baccifera, Woodfordia fruticosa* etc. are occasionally met with in this zone.

Interestingly, *Natsiatum herpeticum* (Icacinaceae) has been collected during the present survey which is listed as a rare plant (Saxena and Brahmam 1984) for Orissa state. *Aegle marmelos, Michelia champaca, Nyctanthes arbortristis* are found in abundance in Kapilas. The leaves, flowers and fruits of these plants are used for the ritual activities connected with Lord Chandrasekhar. In addition to these, *Artocarpus heterophyllus, Mangifera indica* etc. are gregarious in the area which provide fruits to the nearby inhabitants as well as to the wild animals. In all 30 tree species 65 shrubs and 92 herbs have been collected, identified and catalogued. All these plants have been preserved and are housed in the herbarium of P. G. Dept. of Botany, Utkal University, Bhubaneswar.

ACKNOWLEDGEMENTS

We thank the Professor & Head, P. G. Dept. of Botany, Utkal University, Bhubaneswar for providing facilities for this work. Financial assistance from the Botanical Survey of India is also gratefully acknowledged.

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BHUBANESWAR-751 004,
August 17, 1985.

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SENAPATI, N. & TRIPATHY, P. (1972): Orissa District Gazetteers — Dhenkanal. Orissa Government Press, Cuttack.

29. ADDITIONS TO THE PTERIDOPHYTIC FLORA OF NAINI TAL

During the course of the preparation of the Pteridophytic flora of Naini Tal six ferns and fern allies were collected and identified with the help of available floras. A perusal of earlier literature and records indicate that these species were neither collected nor reported by earlier workers from Naini Tal. This note, records these addition to the Pteridophytic flora of Naini Tal along with other relevant informations.

The voucher specimens are housed in the Herbarium, Botany Department, D. S. B. College, Kumaun University, Naini Tal. Field number of each species along with collector's name is given in brackets.

Lycopodiaceae

1. **Lycopodium setaceum** Buch.-Ham., Prodr. Fl. Nepal 18, 1825; Spring, Monogr. Lycopod. 42. 1847; Clarke, Trans. Linn. Soc. Lond. 2 (Bot.) 1: 590, 1880. *L. pulcherrimum* Wall. ex Hook. et Grev., Bot. Misc. 2: 367, 1831. *L. gramineum* Spring, Monogr. Lycopod. Part 2: 19, 1848.

Occurs frequently on shady - moist moss laden boulders. Rarely as an epiphytic on *Pinus roxburghii* and *Quercus leuchotrichophora* trees between 1,300-1,400 m. Bajoon (YPSP 105).

Polypodiaceae

2. **Drynaria propinqua** (Wall. ex Mett.) J. Smith, Journ. Bot. 4: 62, 1842; Bedd., Handb. Ferns Brit. India Suppl. 339, t. 189, 1892. *Polypodium propinquum* Wall. ex Mett., Farngatt. Polypod. 120, 1857; Clarke, Trans. Linn. Soc. Lond. 2 (Bot.) 1: 556, 1886.

Extremely rare species occurring at 1,400 m. Usually growing on moss covered tree trunks. Bajoon (YPSP 198)

Thelypteridaceae

3. **Pronephrium nudatum** (Roxb.) Holttum, Blumea 20 (1): 111, 1972. *Polypodium nudatum* Roxb., Calcutta Journ. Nat. Hist. 4: 491, 1844. *P. multilineatum* Wall. ex Hook. Sp. Fil. 5: 11, 1863. *Thelypteris multilineata* (Wall. ex Hook.) Morton, Amer. Fern Journ. 49(3): 113, 1959; Nayar, Rec. Bot. Surv., India 20 (2): 16, 1973. *Nephrodium moulmeinense* Bedd., Ferns Brit. India 18, 1876 et Handb., Ferns Brit. India Suppl. 73, 1892. *Dryopteris moulmeinsis* (Bedd.) C. Chr., Index Fil., 278, 1905. *Abacopteris multilineata* (Wall.) Ching, Bull. Fan. Mem. Inst. Bot. 8: 253, 1938.

A rare species occurring at 600 m by the side of streamlets in deep shady ravines in sal forest. Bhujia Ghat (YPSP 172).

Nephrolepidaceae

4. **Nephrolepis cordifolia** (Linn.) Presel., Tent. Pterid. 79, 1836; Clarke, Trans. Linn. Soc. Lond. 2 (Bot.) 1: 540, 1880: Bedd., Handb. Ferns Brit. India Suppl. 282, t. 144, 1892. *Polypodium cordifolium* Linn., Sp. Pl. 1098, 1753. *Aspidium tuberosum* Bory, Willd. Sp. Pl. 5: 234, 1810. *Nephrolepis tuberosa* Presl., Tent. Pterid. 79, 1836.

This species is commonly cultivated for indoor and outdoor decoration. Naini Tal (YPSP 98).

Aspidiaceae

5. **Polystichum lentum**(D. Don) Moore, Index Fi, 86, 1858. *Aspidium lentum* D. Don,

Prodr. Fl., Nepal 4, 1825. *A. auriculatum* Swartz var. *lenta* Clarke, Trans, Linn. Soc. Lond. 2 (Bot.) 1: 507, 1880. *Polystichum auriculatum* (Linn.) Presl. var. *lenta* Bedd., Handb. Ferns Brit. India 204, 1883.

A rare species. Grows on moist, shady rocks in ravines at 1,300 m. Bajoon (YPSP 85).

VITTARIACEAE

6. **Vittaria flexuosa** Fee, 3 We Mem., 16. 1851-52; Clarke, Trans. Linn, Soc. Lond. 2 (Bot.) 1: 572, 1880; Bir, Res. Bull. Punjab Univ. (n.s.)., 13: 22. f. 20-23, 1962. *V. lineata* sensu Bedd., Ferns South India, t. 54, 1883; et Handb., Ferns. Brit. India 407, 1883.

Ecology:- A rare species and grows on moss covered tree trunks in deep shady ravines at 1,300 m. Jeolikote (YPSP 102).

ACKNOWLEDGEMENT

We are thankful to Prof. B. S. Mehrotra, Head, Botany Department, D.S.B. College, Kumaun University, Naini Tal for providing facilities and encouragement.

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July 20, 1985.

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G. S. RAWAT
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30. FLORAL BIOLOGY OF *CASSIA ANGUSTIFOLIA* VAHL

INTRODUCTION

Cassia angustifolia Vahl. (Caesalpineaceae) a perennial plant indigenous to Somaliland and Arabia, which is now grown extensively in South India. It grows wild in certain parts of Kutch. The leaves and pods of the plant contain glycosides called 'sennosides' and have been long used for laxative purpose by allopathic and indigenous medical practitioners. India has been the exporter of the crude drug (leaves and pods). The agronomical, phytochemical and pharmacological aspects of 'Senna' have been studied in detail. Other botanical aspects such as floral biology, genetics, etc. have not received attention. The floral biology of Senna is described here.

MATERIAL AND METHODS

Floral biological studies were conducted during the years 1983-84 on Senna plants raised at Central Research Farm, Jodhpur. Observations were recorded from tagged flowers on bud development, anthesis and dehiscence. Stigma receptivity was studied by visual observation and experimentation by hand pollination. Observations on pollens, pollinators, fruit set and post-fertilisation development were also recorded.

RESULTS AND DISCUSSION

a) *Flower bud development*: In Indian Senna plants, initial flowering starts when they are 90 to 100 days old. A succession of blossoms appear at periodic intervals thereafter. In Russia, senna is reported to commence flowering earlier, at the age of 50 to 60 days (Nikolaeva 1973). The inflorescence buds appear in the axils of the pinnately compound leaves. The smallest recognisable size of inflorescence bud is 5 mm., when the young leaves are 2.5 to 3.7 cm. long (mature leaf measures 15 cm). A fully mature inflorescence (raceme) is 10±1 cm long, normally bearing 13 to 15 floral buds spirally on the rachis. The smallest individual floral bud measuring 3 mm becomes 13 mm (a day before anthesis) in an interval of about 15 to 20 days. Few upper most buds on the rachis do not reach anthesis. Young buds are pale yellowish green and bright yellow when mature. A thin membranous bract protecting the bud falls off when the bud matures.

b) *Anthesis and dehiscence*: Anthesis proceeds basipetally, from basal flowers towards apex, in order of maturity. It is observed that 86 per cent flowers opened between 4 a.m. and 6 a.m., while 14 per cent opened from 6 a.m. to 8 a.m. Russian senna flowers are reported to open during night in warm weather and during day in autumn (Nikolaeva 1973). It takes about 15 days for all the flower buds on the inflorescence axis to complete anthesis. Anthers are variable in size and three of them are staminodes. Two largest anthers and the style are curved. Dehiscence is apical and commences within 1-3 hours of anthesis. The release of pollen is slow and gradual extending for over about 24 hours. Pollen grains are triangular and 3.8μ to 4.1μ in size. Pollen fertility is about 98%. The buds and the bright yellow flower attract ants, flies, wasps and moths (*Pieris brassicae,* especially), due to a sugary secretion. These insects help in cross pollination as pollens have been observed on their bodies. It takes 10 to 14 days for completion of anthesis.

c) *Fruit set and Post fertilisation developments*: Experimental study shows that stigma becomes receptive soon after anthesis. No fruit set was recorded when hand pollinated 24 hours before anthesis. It is also evident that both self and cross pollination exists. Under normal and natural conditions, fruit set was found to be 74.48%. The carpel is 7.5 mm long a day before anthesis, 10 mm on the day of anthesis and 12 mm long on a day after anthesis. Soon after fertilisation, the sepals bend backwards, wither and fall away along with stamens within 48 hours. The bright yellow petals which are more persistent, bend downwards, yellow colour gradually bleaching to white. Within one week of anthesis, all parts are shed. Style is most persistent, dried on the tip of pod. Fruit is a legume, about 5×2 cm in size and takes about 25±3 days to mature. After this period, the mature green pods start turning dark brown to black (ripening). Nikolaeva (1973) reported that fruit development took 12 days and seed ripening occurred after 40-45 days of anthesis. Each pod contains upto 8 seeds normally. The rachis (inflorescence axis) grows from 10±1 cm (at the time of anthesis) to 13±1 cm., when the pods mature, so that the pods are well apart.

ACKNOWLEDGEMENTS

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V. A. AMALRAJ

DIVISION OF PLANT STUDIES,
CENTRAL ARID ZONE RESEARCH
INSTITUTE, JODHPUR,
July 4, 1985.

REFERENCE

NIKOLAEVA, I. G. (1973): *Cassia angustifolia*, biology of blooming and seed formation in the south of the Turkmen SSR. *Izv. Akad. Nauk. Turkm SSR Ser. Biol. Nauk. 4*: 17-22.

31. NEW DISTRIBUTIONAL RECORDS FROM CHAMOLI DISTRICT IN N. W. HIMALAYAS

INTRODUCTION

The district of Chamoli, lies between 29° 55′ 32″ and 31° 4′ 22″ latitude and 78° 54′ 26″ and 80° 6′ 14″ longitude, covering an area of 9,125 Sq. Km. The district is bounded on the east by the district of Almora and Pithoragarh, on south by the district of Pauri Garhwal, on west by districts of Uttarkashi and Tehri and on the north by the snowy ranges of Tibet.

ENUMERATION

We have been engaged in a study of the flora of Chamoli district for some time and report here 10 species for the first time from this part of N.W. Himalayas. The flowering and fruiting time together with range of altitude of occurrence is also given. The numeral given immediately after the place of collection indicates the collection number of the plant from the locality concerned.

The herbarium specimens cited are deposited in the herbarium of Botany department, Meerut University, Meerut.

Nymphaea alba Linn. Hook. f. Fl. Brit. Ind. 1: 114, 1872, LN Kamal. (Nymphaeaceae) Aquatic herb with thick, creeping rhizomes. Flowers, white, solitary on long peduncles.

Fl. & Fr. June-Oct.

Coll: Benital. Alt. 1830 m.

Anaphalis aristata DC. Hook. f. Fl. Brit. Ind. 3: 285. (Asteraceae) Erect, wooly herb. Heads turbinate, in globose, corymbose clusters.

Fl. & Fr. Aug.-Oct.

Coll: Way to Kedarnath 4115. Alt. 2438-3048 m.

Bidens cernua Linn. Hook. f. Fl. Brit. Ind. 3: 309 (Asteraceae) Erect, glabrous herb with fistular stems. Leaves opposite, auricled. Heads yellow, erect or drooping. Outer involucre leafy. Achenes cuneiform, truncate, margins recurved, spiny; apex with 1-4 bristly pappus.

Fl. & Fr. Aug.-Oct.

Coll: Benital 3335. Alt. 1830 m.

Parthenium hysterophorus Linn. Sp. Pl., 988, 1753. (Asteraceae) An erect, tufted, leafy herb. Stem scabrid hairy, grooved. Heads heterogamous, in axillary or terminal, leafy, corymbose cymes. Achenes obovae, black.

Fl. & Fr. Aug.-Nov.

Coll: Near Gwalior 4290. Alt. 800 m.

Commelina suffruticosa Blume, Enum. 3, 1830; Hook. f. Fl. Brit. Ind. 6: 374, 1892 (Commelinaceae) Scandent herb. Leaves large, lanceolate, scabrid-pubescent. Sheath auricled, hairy-fringed on the mouth. Flowers white, in ovate-cordate spathe. Seeds 2, ellipsoid, rugose, puberulous.

Fl. & Fr. May-Nov.

Coll: Tigaddi 2012. Alt. 1350 m.

Ceratophyllum demersum Linn. Hook. f. Fl. Brit. Ind. 5: 639 (Ceratophyllaceae) Submerged, aquatic herb. Leaves pinnatisect, segment filiform, Flowers solitary axillary, monoecious.

Fl. & Fr. Aug.-Oct.

Coll: Near Gauchar 2674. Alt. 700 m.

Wolffia arrhiza (Linn.) Horkel ex Wimm. Fl. Schles. 140, 1857; Fl. Brit. Ind. 6: 306 (Lemnaceae). Small, floating herb. Fronds sub-globose beneath.

Fl. & Fr. Aug.-Oct.

Coll: Karankund 1089. Alt. 305-914 m.

W. microscopia (Griff. ex Voigt.) Kurz., Jour. Linn. Soc., Bot. 9: 265, 1867; Fl. Brit. Ind. 6: 558. (Lemnaceae) Minute, floating, aquatic herb. Frond subglobose, tapers into conical appendage beneath.

Fl. & Fr. Sept.-Nov.

Coll: Langasu 4798. Alt. 305-762 m.

Najas graminea Del. Hook. f. Fl. Brit. Ind. 6: 569. (Najadaceae) Submerged, aquatic herb. Leaves linear to subulate, with dentate margins. Flowers solitary or 2-4 together. Seeds areolate.

Fl. & Fr. Aug.-Oct.

Coll: Hailuri 4674. Alt. 610-1200 m.

Brachiaria villosa (Lam.) A. camus var. **barbata** Bor. Var. Nov.; Bor in Grass. Bur. Cey. Ind. Pak. 286, 1960 (Poaceae) Erect, decumbent, villous-hairy annual grass. Spikelets in hairy panicles. Upper glume, hairy tipped, equalling the spikelet.

Fl. & Fr. Aug.-Nov.

Coll: Gwaldam 4218. Alt. 1200 m.

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May 30, 1985.

Y. S. MURTY

32. *UROCHLOA PANICOIDES* P. BEAUV. (POACEAE) IN SOUTH INDIA

(*With a plate*)

Urochloa panicoides, an annual ruderal serves as an excellent fodder for cattle. A scrutiny of literature reveals its wide distribution in India both in plains and on the Himalayas upto about 5000 ft. It contributes much to the greenness of disturbed waste lands and is also a dominant weed in cultivated dry lands during monsoon. In Australia it was used in 1940s to smother weeds on black soils (Buckley 1959). The species occurs with four morphologically distinct varieties (Bor 1960) *viz., Urochloa panicoides* P. Beauv. var. *panicoides,* var. *pubescens* (Kunth) Bor, var. *marathensis* (Henr.) Bor and var. *velutina* (Henr.) Bor. While collecting the species of *Urochloa* for Biosystematic studies, all four varieties were collected from various parts of South India. All the floristic accounts record and describe the species with var. *panicoides* and/or var. *pubescens,* while the var. *velutina* and var. *marathensis* are not properly recognised in regional herbaria such as MH and BSI.

TAXONOMIC STATUS

Urochloa panicoides belongs to the tribe Paniceae of Panicoideae. The species was first described by de Beavois (1812). Various classificatory exercises have been made on the species by different authors. Kunth (1829) described the pubescent variant as *Urochloa pubescens.* In view of the common occurrence of glabrous and pubescent spikelets and submarginal fringe of hairs in the lower lemma in most of the species of the genus *Urochloa,* Stapf (1929) abstained from giving these states varietal names and preferred to distinguish to them as forms. But Henrard (1922) raised the var. *marathensis* to species *Urochloa marathensis* and placed the var. *velutina* as a variety under this new species. In 1960 Bor, made a new combination of four varieties under *U. panicoides.*

The species is very similar to *Brachiaria ramosa* with which it can be rather easily confused. Its distinguishing characters are comparatively large abaxial spikelets and a short fine mucro from the obtuse apex of the upper lemma. Species description is given in many floristic accounts. The key for identification of the varieties on the basis of additional characters (Bor 1960) is as follows;

Lower lemma without a fringe of bristles.
  Spikelets glabrous .... *U. panicoides* var. *panicoides*
  Spikelets pubescent .... var. *pubescens*
Lower lemma with a conspicuous fringe of bristles.
  Spikelets glabrous .... var *marathensis*
  Spikelets pubescent .... var. *velutina*

TABLE 1

MEAN SPIKELET LENGTH (MM.) AND WIDTH (MM.) OF FOUR VARIETIES OF *U. panicoides* IN THREE POPULATIONS

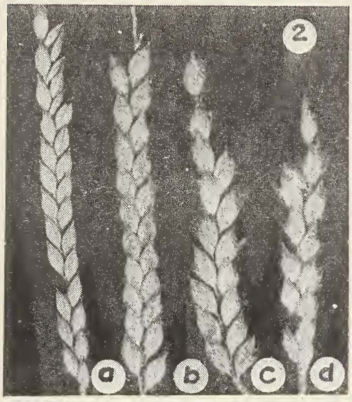
		var. *panicoides*	var. *pubescens*	var. *marathensis*	var. *velutina*
Agric. Coll.	Length	4.43±0.24	4.29±0.13	4.47±0.15	4.43±0.20
Poona	Width	2.10±0.08	2.24±0.12	2.27±0.13	2.25±0.11
Agric. Coll.	Length	3.98±0.29	3.79±0.09	4.02±0.09	4.14±0.08
Dharwar	Width	1.89±0.09	1.97±0.09	2.00±0.04	2.04±0.06
Manasagangotri,	Length	3.68±0.08	3.64±0.13	3.70±0.13	4.04±0.05
Mysore	Width	1.79±0.12	1.85±0.06	1.89±0.05	1.89±0.11

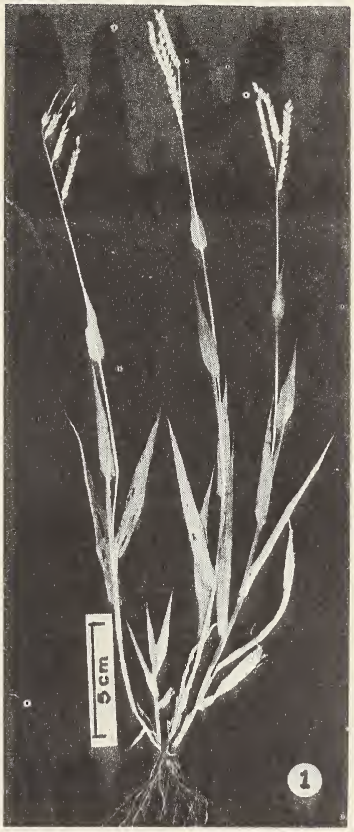
POPULATION STUDIES

The previous studies clearly show the existing confusion in the taxonomic position of these taxa. Hence an attempt has been made to answer these. About 400 collections were made from various parts of South India, which include all the four varieties. Minor differences in number of tillers per plant, leaf size, leaf pubescens, number of racemes, raceme length, number of spikelets, spikelets size etc., were noted between the varieties in different populations.

Variations observed in spikelet size and degree of pubescens in three populations where all the four varieties were growing intermixed are illustrated here. Habit of the species is shown in fig. 1 (Plate) and the varieties can be distinguished by the spikelets on the racemes (Plate, fig. 2). Mean length and width of spikelets of all the four varieties of three populations are given in Table 1.

The collections (Basavaiah 233-236) from Agriculture college fields, Poona exhibit the largest spikelets in all the four varieties and conspicuous pubescence in the pubescent varieties (Plate, fig. 3a-3d). The collections Basavaiah 273-276) from Agriculture College fields, Dharwar showed medium sized spikelets





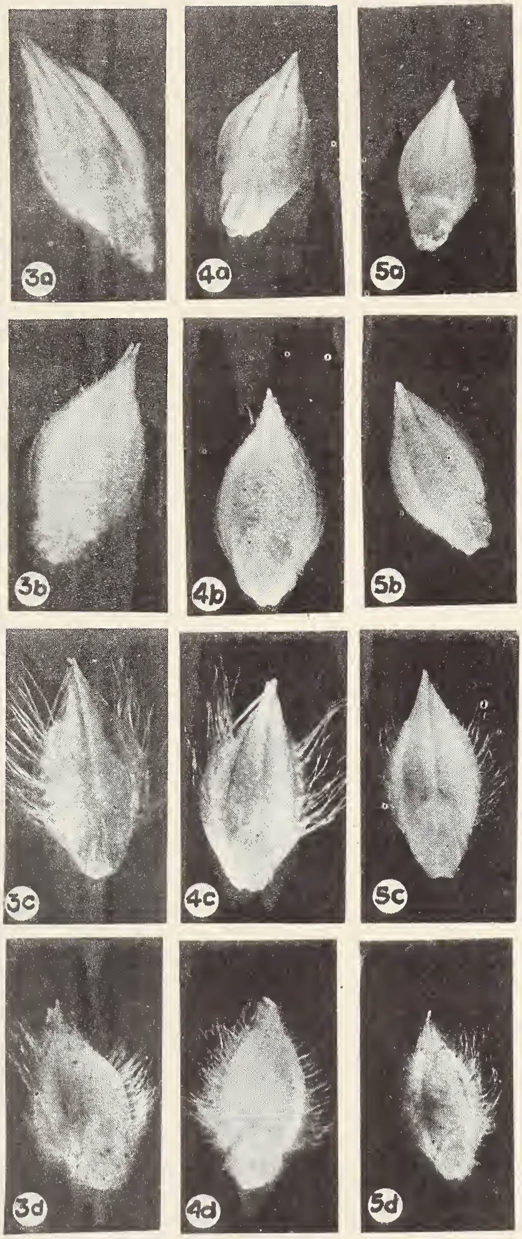

3a
4a
5a
3b
4b
5b
3c
4c
5c
3d
4d
5d

Fig. 1. *Urochloa panicoides* P. Beauv. Fig 2. Racemes of four varieties of *U. panicoides*. a) var. *panicoides*; b) var. *pubescens*; c) var. *marathensis*; d) var. *velutina*.

Fig. 3a-3d. Spikelets of four varieties collected from Poona.

Fig. 4a-4d.	-do-	Dharwar.
Fig. 5a-5d.	-do-	Mysore.

with moderate pubescence (Plate, fig. 4a-4d). Similarly some of the collections (Basavaiah 52, 53, 60 & 100) of Manasagangotri, Mysore showed smaller spikelets and inconspicuous pubescence (Plate, fig. 5a-5d). Such collections from Mysore pose difficulty to differentiate the varieties with the existing key. Hence other aspects of Biosystematic study of this exomorphic complex have to be made to delimit the taxa. The herbarium specimens cited, are lodged in the herbarium (MGM), University of Mysore, Manasagangotri, Mysore.

ACKNOWLEDGEMENTS

We thank the authorities of MH and BSI for herbarium and library facilities. The senior author thanks UGC, New Delhi, for the award of a Research fellowship.

BASAVAIAH
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33. A CONTRIBUTION TO THE MOSS FLORA OF NORTH WESTERN GHATS, INDIA

Although the moss flora of Eastern India, Himalayas and the Nilgiris in the South are well known, there are comparatively few reports of mosses for the bryologically rich area of the Western Ghats. This is specially true for Mahabaleshwar and surrounding areas in Northern Western Ghats. Dabhade (1966, 1969, 1970) reported 10 mosses from the Western Ghats while Tixier (1979) listed 21 species from Mahabaleshwar. Barring these reports, only sporadic references to mosses exist for this region.

On 27th to 29th January, 1984, a collection of bryophytes were made by us at three localities Mahabaleshwar, Poona and Khandala in North Western Ghats, the outcome of which is this report.

The Western Ghats are geologically formed of basaltic lava of varying thickness, the top part of which is laterite. Mahabaleshwar receives an annual rainfall of 700 cm, mostly during the South West Monsoon months of June to September. The hottest months are April and May.

Collection and list of localities:

Voucher specimens are deposited at the Bryophyte Herbarium of the Botany Dept., Universiti Malaya (KLU), Bryophyte Herbarium of the Botany Dept., Poona University and occasional duplicates at Missouri Botanical Garden (MO). A list of collection sites by collection numbers follows:

400–424 Khandala, Alt. 850 m., January 27th., 1984.
425–454 Mahabaleshwar, Alt. 1382 m. Along road from Mahabaleshwar Town to Pratapgad Road, January 28th., 1984.
446–470 Mahabaleshwar, Alt. 1320 m. Road from Pratapgad to Lodwick point, January 28th, 1984.
471–473 Poona University Campus, 1000 m, January 29th, 1984.

List of species.

Species marked with a single asterisk are new to the moss flora of Western Ghats.

FISSIDENTACEAE

1. *Fissidens ceylonensis* Dozy & Molk. – 432.
2. **F. diversifolius* var. *rubricaulis* (DIX.) Norkett in Gangulee — 470.
3. *F. mitteni* Par. — 468b.
4. **F. polysetulus* C. Muell. ex Gangulee & Norkett — 468a
5. **F. pulchellus* Mitt. — 433.
6. *F. ranchiensis* Gangulee — 4216, 434, 437.
7. *F. sylvaticus* Griff. — 460, 463, 464, 465a.
8. **F. zollingeri* Mont — 431, 435.

DICRANACEAE

9. *Campylopus aureus* Bosch & Lac. — 438, 451, 452.
10. **C. durelli* Gangules — 456.
11. *C. gracilis* (Mitt.) Jaeg. — 458.
12. *C. richardii* Brid. — 446, 450.

LEUCOBRYACEAE

13. *Octoblepharum albidum* Hedw. — 408.

POTTIACEAE

14. *Barbula indica* (Hook.) Spreng — 402, 403, 410.
15. **Gymnostomum calcareum* Nees & Hornsch. — 405b, 420.
16. *Gymnostomiella vernicosa* (Hook.) Fleisch. — 403.
17. *Hymenostylium recurvirostre* var. *aurantiacum* (Mitt.) Gang. — 460, 465a, 466, 473.
18. *Hyophila involuta* (Hook.) Jaeg. — 400, 401, 405a, 418a, 428.

FUNARIACEAE

19. *Funaria hygrometrica* Hedw. — 426.

BRYACEAE

20. *Anomobryum auratum* (Mitt.) Jaeg – 441.
21. *Brachymenium acuminatum* Harv. — 4186.
22. *B. indicum* (Dozy & Molk.) Bosch & Lac. — 442, 459.
23. **B. longidens* Ren. & Card. — 454.
24. *Bryum coronatum* Schwaegr. — 407a, 427.
25. **B. plumosum* Dozy & Molk. — 417.
26. *B. porphyroneuron* C. Muell. — 420, 421b.
27. *B. nitens* Hook. — 471, 473.
28. *B. wightii* Mitt. — 445, 456, 465b.

BARTRAMIACEAE

29. *Philonotis hastata* (Duby) Wijk & Marg. — 422.
30. **P. leptocarpa* Mitt. — 407a.
31. *P. longicaulis* (Hampe) Mitt. — 418b.
32. *P. mollis* (Dozy & Molk.) Mitt. — 405b, 421a, 421b.

ERPODIACEAE

33. *Erpodium mangiferae* C. Muell. — 472.

ORTHOTRICHACEAE

34. *Macromitrium sulcatum* (Hook.) Brid. — 430a, 439, 451.

TRACHYPODACEAE

35. *Diaphanodon procumbens* (C. Muell.) Ren. & Card. — 413, 419a, 429, 430a, 438a, 461, 469.
Endemic to Western Ghats.

PTEROBRYACEAE

36. **Pterobryopsis acuminata* (Hook.) Fleisch. — 461.
37. **P. flexipes* (Mitt.) Fleisch. — 413, 416, 432.
38. *P. walkeri* (Broth.) Broth. — 407 b.

METEORIACEAE

39. *Meteoriopsis squarrosa* (Hook.) Fleisch. ex Broth. var. *longicuspis* Nog. — 462.

DALTONIACEAE

40. **Daltonia aristifolia* Ren. & Card. — 443.

ENTODONTACEAE

41. **Entodon laetus* (Griff.) Jaeg. — 458a.

PLAGOTHECIACEAE

42. **Stereophyllum ligulatum* (C. Muell.) Jaeg. — 411, 429b, 430b, 433.

SEMATOPHYLLACEAE

43. **Trichosteleum boschii* (Dozy & Molk.) Jaeg. — 453.

HYPNACEAE

44. **Ectropothecium monumentorum* (Dub.) Jaeg. — 414.

RHYTIDIACEAE

45. **Okamurea hakoniensis* (Mitt.) Broth. — 412.

ACKNOWLEDGEMENTS

We thank Dr. Robert E. Magill for assistance in the identification of the mosses and The Missouri Botanical Garden for financial assistance and facilities provided to one of us (M.A.H.M.) during the preparation of the manuscript.

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April 6, 1985.

N. V. BIRADAR
J. G. VAIDYA

REFERENCES

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34. ON THE IDENTITY OF *HEDYOTIS ERECTA* MANILAL & SIVARAJAN (RUBIACEAE)

We have been working on the taxonomy of the genera *Hedyotis* L. and *Oldenlandia* L. for the last 6-7 years and have published notes (Deb & Dutta 1983, 1985 a, b) on nomenclatural and taxonomic changes involving about 15 species.

Hedyotis erecta Manilal & Sivarajan in Bot. Notiser 129(2): 191. 1976. was distinguished from *H. corymbosa* (L.) Lamk. for (1) invariably erect main shoot with fastigiate branches, (2) stipule with 2 or 3 filiform appendages and (3) testa cells with straight walls.

It is apparent that the authors did not give due consideration to variability and the present circumscription of *H. corymbosa.* The original description of this species has undergone changes from time to time at the hands of different workers, which deserve due consideration to ascertain its differences from other species. It is now generally admitted that *H. corymbosa* is highly polymorphic in habit, shape and size of leaves, number of flowers in a cyme, length of peduncle and pedicel and capsule shape and size, J. D. Hooker, Fl. Brit. Ind. 3: 64. 1880 treated this species under *Oldenlandia* and considered it as very variable. He further observed that "various forms of the plant are distinguished by botanists as species; but these run so much into one another that it is impossible to correlate descriptions exactly with the specimens in Wallich's and Wight's herbaria". It is obvious that Hooker f. (l.c.) reduced to its synonymy several species described by different workers.

Verdcourt in Kew Bull. 30: 296-298, 1975 & Fl. Trop. E. Africa (Rubiaceae part 1): 308-310, 1976 treated under *O. corymbosa* L. 4 varieties, namely, var. *corymbosa,* var. *linearis* (DC.) Verdc., var. *nana* (Bremek.) Verdc. and var *caespitosa* (Benth.) Verdc.

J. D. Hooker (l.c.) treated *O. linearis* as synonymous with *O. heynii* G. Don. Bremekamp (1952) and Hepper (1963) observed that *O. linearis* differs widely from *O. heynii* in arrangement of flowers and testa cells structure, but is closer to *O. corymbosa* being distinguishable by narrow leaves and straight wall of testa cells. Verdcourt (l.c.) considered these variations as of varietal rank and treated *O. linearis* as a variety of *O. corymbosa.*

H. erecta Manilal & Sivarajan does not differ from *O. linearis* DC. in any respect and agrees with it both in description and illustrations. Thus this new species cannot be sustained, and is synonymous with *O. corymbosa* var. *erecta.* Since the genus *Oldenlandia* L. is treated as synonymous with *Hedyotis* L. by the authors of the present note a new combination at varietal rank under the genus *Hedyotis* is proposed as follows.

Hedyotis corymbosa (L.) Lamk. var. **linearis** (DC.) Deb et Dutta comb. nov.

Basionym: *Oldenlandia linearis* DC. Prodr. 4: 425. 1830 (Type: Senegal, Bay of St. Louis, *Perrottet* s.n. (G. holo, P, K iso, DC. microfische!); Bremek. in Veh. Kon Netherl. Akad. Wet. Afd. Natuurk. Ser. 2, 48(2): 258. 1952; Hepper in Fl. West Trop. Afr. ed. 2, 2:211. 1963. *O. biflora auct*., non L., Roxb. Fl. Ind. 1: 422. 1820 & 1: 445. 1832. (Type: Courtallum, *Heyne s.n.* in *Wall Cat.* 868, pro parte CAL!); Roxb. Icon. 1342 CAL!, *H. burmanniana* R. Br. ex *Wall. Cat.* 868, pro parte, 1829, non Schult. 1827. *H. biflora* Smith in Rees Cycl. 17: 15. 1811, non Lamk. 1792 (Type: E. Indies, 1804, *N.E. Kindersley s.n.* LINN microfische!). *O. burmanniana* (Wall.)

G. Don, Gen. Syst. Gard. Bot. 3: 529. 1834. *H. linearis* (DC.) Steud. Nom. Bot. 728. 1840. *O. corymbosa* L. var *linearis* (DC.) Verdc. in Kew Bull. 30: 296. 1975 & Fl. Trop. E. Afr. Rubiac. 1: 309. 1976. *H. erecta* Manilal & Sivarajan in Bot. Notiser 129(2): 191. 1975 (Type: Kerala State, Idimuzhikhal, *Sivarajan* 491 LWG), *Syn. nov.*

Distribution: Tropical E. Africa and India (Throughout).

BOTANICAL SURVEY OF INDIA,
HOWRAH,
May 5, 1986.

D. B. DEB
RATNA DUTTA

REFERENCES

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ANNUAL REPORT OF THE BOMBAY NATURAL HISTORY SOCIETY FOR THE YEAR 1984-85

EXECUTIVE COMMITTEE

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Vice-Presidents

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HONORARY SECRETARY'S REPORT FOR THE YEAR 1984

101st Year

MEMBERSHIP

The membership continue to show a slow but steady increase but there is certainly a pressing need to increase the membership.

Your Committee is examining the constraints which restrict the membership and how best these can be removed to accelerate member recruitment.

The cost of member facilities and the strain it puts on the administration of the Society are also under consideration. The possibility of journal and non-journal membership and more realistic membership dues is being examined. The journal for instance costs the Society Rs. 55 per member plus Rs. 11 towards postage out of a current subscription of Rs. 60!

Details of membership for the past quinquennium, showing members fully paid up on 31st December of each year are given in the statement below:

MEMBERS' ACTIVITIES

Field trips:

During the year one day field trips were arranged largely within the Sanjay Gandhi National Park for Bombay members. These were bird watching treks and included treks from Kanheri Caves to Mamma Bhanjhan, and Chunabatti village to Tulsi Lake. The field trips were well attended and enabled us to introduce members to birds and bird habitats, including vegetation studies and information on other aspects of natural history.

The monthly roadside bird count continues to be operated by a hard core of enthusiastic bird watchers, who have over the years become quite competent in bird identification.

Weekend field trips:

A few limited capacity field trips were organised to acquaint members with nature reserves and habitats within an overnight journey distance of Bombay.

	1980	1981	1982	1983	1984
Ordinary members	764	1044	1137	1533	1762
Corporate members	168	176	162	158	132
Life members	327	349	407	484	562
Compound Corporate members	20	37	52	102	107
Student members	94	165	126	182	192
Honorary Members	3	3	3	3	3
Vice Patrons	—	3	4	4	6
	1376	1777	1891	2466	2764

Members elected in 1984, but not paid	24
Members paid for 1983, but not paid for 1984	218

Nature Camp:

The Centenary Nature camp was organised at Chopta (10,000 ft) in Garhwal Himalayas. The Natural beauty of this area is complemented by the variety of its birdlife including such spectacular forms as the Monal Pheasant.

There were two batches of 25 persons each from 27th September to 6th October. Members were taken to Dungalbetta, a trek of 4 km and on the way they saw varieties of Himalayan flowers and birds. Members were also taken to the Musk Deer breeding Centre at Karchula Khark.

MEMBER FIELD SURVEYS AND PROJECTS

Study of Nilgiri Langur in Mundanthurai, Tamil Nadu:

Dr. Johnsingh initiated this project. The study is broadly divisible into two categories, i.e. (1) Survey of the distribution of the Nilgiri Langur troops on Mundanthurai Plateau and (2) an indepth study on the feeding ecology and ranging patterns of troop which lives in the Gallery Forest to the east of the confluence of the river Tambiraparani and Servelar in Tamil Nadu. (Supported by the Salim Ali Nature Conservation Fund).

In search of the Malabar Civet:

Mr. E. R. C. Davidar undertook this project to rediscover the Malabar Civet. No attempt has been made recently to ascertain the status of the Malabar Civet.

Mr. Davidar conducted an enquiry in the Wynaad and Malabar areas to determine if the civet still existed. Posters were prepared and circulated in the former areas of distribution of the species. (Supported by the Salim Ali Nature Conservation Fund). Report available.

Karvi observations at Mahabaleshwar area:

The strobilanthes which flowers every eighth year synchronously flowered in 1984. Observations on flowering period, pattern mechanism of pollination, period of fruit setting and maturation were made by a team led by Prof. P. V. Bole. (Supported by the Salim Ali Nature Conservation Fund.) Report available.

Status survey of Honey-Guide at Bhutan:

Mr. Sunjoy Monga undertook this project. Most of the information currently available on *I. xanthonotus* is from occasional notes published in various journals. A preliminary survey was done at Bhutan for a possible long term study of the ecology of this species. (Supported by the Salim Ali Nature Conservation Fund.) Report available.

Bastar Buffalo Study:

Mr. H. K. Divekar initiated a project to survey and study the status of the wild buffalo in Bastar district. This is the only population of the species in peninsular India and is under considerable stress. (Supported by the Pirojsha Godrej Fund).

Natural History of the Garhwal Himalayas:

A team of young members of the Society namely Dr. (Miss) Meena Haribal, Mr. Nitin Jamdar, Mr. Hemant Shinde and Ms. Arti Kaikini trekked in the Garhwal Himalayas studying the natural history of the hills. The expedition was supported by the Pirojsha Godrej Fund. Report available.

Malshej Ghat Bird study:

Mr. Abdulali carried out a study of birds at Malshej Ghat at the foot of the Harischandra Gadh. During monsoon this area is covered with thick mist. Due to poor visibility several birds while flying through this area hit the wall of the rest house and die. The causative factors were examined. (Supported by Charles McCann Fund.)

Avifauna of plantations:

Agriculture demands large areas of land and creates changes in ecosystems. With the current emphasis on social forestry plantations of quick growing species of trees have come up, which have their own ecosystem quite different from the ecosystem of natural forests. Mrs. Tara Gandhi is studying the comparative ecology of bird populations of plantation with those of natural forest habitats in the same area. (Supported by the Salim Ali/Loke Wan Tho Ornithological Research Fund).

PUBLICATIONS

Journal:

During the year the August and December issues for 1983, Vol. 80 (2) & (3) and the April and August issues for 1984, Vol. 81 (1) & (2) were published. The 959 pages of these journals held 224 articles and notes. We received from members and others 257 articles and notes for publication in the journal in 1984.

Hornbill:

The Hornbill continued to maintain its popular appeal to members and is a reflection of member talent in different fields of natural history. A special issue of the Hornbill giving the complete history of the Society was published during the year.

THE BOOK OF INDIAN BIRDS continued to be the best seller among the Society's Publications followed by the BOOK OF INDIAN ANIMALS. Both publications were reprinted during the year.

The year also saw the release of the BOOK OF INDIAN REPTILES, the latest addition to the Society's list of natural history books.

SALES STATEMENT

	Sales in		Complimentary copies	Balance stock 31.12.84
	1983	1984		
The Book of Indian Birds	2067	1469	6	44
The Book of Indian Animals	710	692	1	485
Some Beautiful Indian Trees	292	225	1	1280
Glimpses of Nature in India Booklet	548	434	3	81
Snake Chart	27	37	–	282 (Including soiled copies)
Checklist of the Birds of Maharashtra (2nd edition)	130	83	1	1550
Checklist of the Birds of Delhi, Agra & Bharatpur	153	18	–	35
A synopsis of the Birds of India and Pakistan	103	68	1	1514
Grasses of Western India	95	66	1	257
Some Beautiful Indian Climbers & Shrubs	187	162	2	2208
A Pictorial Guide to the Birds of the Indian Sub-continent	338	3811*	4	4863
A Century of Natural History	263	269	93	2311
The Book of Indian Reptiles		725	55	4220

* including 2063 copies sold by OUP.

Book under preparation:

ENCYCLOPEDIA OF INDIAN NATURAL HISTORY

Centenary Publication 1883-1983

Owing to various problems the Encyclopedia is still pending publication. The major portion of the work has been completed and we hope to publish this volume in 1986.

THE BOOK OF INDIAN TREES

The preparation of the material for this book by Prof. K. C. Sahni is in hand and photographs/transparencies of the 150 common trees in India which will be described are being collected.

CONSERVATION

The Society continues to be recognised by the Central and State Governments in India and by International Organisations abroad as an authoritative source for information on conservation of wildlife and natural resources. The recognition is expressed in the form of association of its officials with State and Central Wildlife Advisory Boards and representation on the specialist groups of the Species Survival Commission of the International Union for the Conservation of Nature and Natural resources.

The Curator represented the Govt. of India at the Conference at Groningen, Netherlands of the parties to the Convention on the Conservation of Wetland Habitats.

At the instance of the Govt. of India, the Curator assisted by Dr. R. B. Grubh and Mr. Hussain visited the Gir Forest on a fact finding survey with reference to the disposal of trees felled by the 1982 cyclone. The report examined this problem as well as status of wildlife particularly the Lion.

UNIVERSITY DEPARTMENT

Recognition for M Sc and Ph D in Plant Studies:

The University of Bombay recognised the Bombay Natural History Society under section 46 of the Bombay University Act, 1974 for guiding student for M Sc and Ph D degrees in the subjects of Botany (Field Botany) for a period of 3 years.

Additional seats:

The University was requested to consider the possibility of increasing the number of students, we can register from 10 to 50 for M Sc and Ph D in Field Zoology (Ornithology, Mammals, and Herpetology).

We have the following students registered for M Sc and Ph D at the Society.

Student	M.Sc.	Guide	Financial support
Mr. Aloysius Gnanasekar	Ecology of Amphibia of Sanjay Gandhi National Park	Mr. J. C. Daniel	Nil
Mr. Ranjit Manakadan	Ecology of the Great Indian Bustard Habitat	– do –	Nil
Mrs. Tara Gandhi	Bird communities of exotic tree species with special reference to *Casuarina*	Dr. Sálim Ali	Fellowship from Sálim Ali/Loke Wan Tho Fund
Mr. Shahid Ali	Ecology and behaviour of the Grey Partridge *Francolinus pondicerianus*	– do –	– do –
Mr. S. C. Tewari	Ecology of the Musk Shrew *Suncus murinus* with emphasis on breeding biology, food habits, home range and territoriality	Mr. J. C. Daniel	Nil
Mr. Bharat Bhushan	The Food and feeding behaviour of the Great Indian Bustard *Choriotis nigriceps.*	– do –	Nil
Mr. Alagar Rajan	Ecology of Spotted and Ring Doves	Dr. R. B. Grubh	Nil
Mr. Vibhu Prakash	Biology of Raptors	Dr. V. S. Vijayan	Nil
Mr. Gurmeet Singh	Ecology of Bank Myna	Dr. R. B. Grubh	Nil
	Ph.D. in Field Zoology		
Mrs. Lalitha Vijayan	Comparative Biology of Drongos with special reference to Ecological Isolation	Dr. Sálim Ali	Fellowship from Sálim Ali/Loke Wan Tho Fund
Mr. Anwarul Islam	Ecology of the Laughing Thrushes of India with special reference to the Endemic species	Dr. Sálim Ali	– do –
Mr. U. Sridharan	Ecology of Residential Ducks in Keoladeo National Park	Mr. J. C. Daniel	Nil
Mr. Goutam Narayan	Birds of Prey	– do –	Nil
	Ph. D. in Plant Studies		
Mr. Manek Mistry	Contributions to the Flora of Ratnagiri District in Maharashtra	Prof. P. V. Bole	Nil

NATURE EDUCATION SCHEME

During the year 475 schools in Bombay, Thane and Kalyan were contacted and about six thousand students participated in our different activities. Besides school students 280 trainee teachers from 4 B.Ed. colleges and 110 trainee teachers from 2 D.Ed. colleges participated in our activities.

Orientation programme on environmental education for the trainee teachers of P.V.D.T. college was arranged. This included lectures and a visit to the Society. As a part of National Sponsorship Programme for 150 Municipal school students at R.C.F., Chembur, a slide talk on birds around Bombay was delivered and the students were taken out for birdwatching. The World Forestry day celebrations included a wildlife quiz programme for the students of 8th, 9th standard. Six schools participated. The programme was later broadcast on AIR in their "Wonderland-world" programme.

Field trips continued to be a major activity and 37 field trips to the Sanjay Gandhi National Park were organised as also one trip to Karnala Bird Sanctuary and two field trips to Khandala. 1500 students participated.

Throughout the year talks illustrated with slides on birds, animals, insects and plants were arranged in different schools and colleges. Films on wildlife were shown in a number of schools and colleges including Range Forest School at Chandrapur.

Tree planting was organised during the World Environmental Day with the help of World Wildlife Fund-India and 10 schools participated.

RESEARCH FUNDS

Sálim Ali Nature Conservation Fund:

Assistance from this source was given to members for field projects (see under Member's activities).

Sálim Ali/Loke Wan Tho Ornithological Research Fund:

Assistance in the form of fellowships was extended to field researchers in ornithology (see under University Department).

Godrej Fund:

Assistance was given to members for field activities in Bastar and the Himalayas (see under Member's activities).

Charles McCann Fund:

Assistance was given to a member to study birdlife in the Malshej Ghat area of Maharashtra (see under Member's activities).

DONATIONS

The Society is deeply grateful to the following Institutions, Organisations and individuals for substantial donations towards the activities and welfare of the Society.

	Rs. P.
General donation:	
Calcutta Tea Trading Co.	1,500.00
Ostrum Enters Trust	1,064.40
Bombay Exports	1,000.00
Mr. Sidharaj Hamirmal Bafna	750.00
Mrs. Kanak Kumari H. Bafna	750.00
Mr. Harshand H. Bafna	750.00
Mr. Ajit Kumar Bafna	750.00
Tehmina K. Katrak Charitable Trust	500.00
Mr. J. P. Elijah	123.00
Mr. Prabhakar Thakur	101.00
Centenary donation:	
Mr. A. K. Stuart	801.69
Mr. C. V. Rajeevan	251.00
Nature Education Scheme:	
Mr. Trevor Price	500.00

Sálim Ali Nature Conservation Fund:

Dr. Sálim Ali	9,000.00

Life Membership Donation:

Mr. Ashwin Mehta	500.00

Charles McCann Fund:

Mr. Schandhai	600.00
Mr. Akbar Abdulali	600.00
Mr. H. Abdulali	7,500.00

Plant Study Fund:

United Phosphorus Pvt. Ltd.,	50,000.00
Dr. Sálim Ali	1,000.00
Mr. T. J. Roberts	874.20
Dr. C. V. Kulkarni	600.00
Mr. S. Joseph Wright	586.87
Mr. K. R. Sethna	500.00
Mr. Ashok Kumar	500.00
Darbar Shri Alkhacher Charitable Trust	500.00
Mr. M. A. K. Stuart	465.00
Mr. David Challinor	435.00
Mr. N. S. Talekar	394.78
Mrs. A. H. Patel	300.00
London A/c Luc Hoffman	267.80
Mr. Franklin L. Wesber Councillor	200.00
Mr. Berry Bean	206.13
Mr. S. Moolgaokar	200.00
Ms. Mary R. Halle	200.00
Tia Rai and others	175.00
Thomas Gene Benedict	154.01
Mr. H. K. Divekar	150.00
Mr. R. D. Hodgkins	139.97
Ms. Anna Barbara Fischer	107.48
Mr. S. B. Motiwala	104.00
Mr. John R. Oppenheimer	101.00
Ms. Perin M. R. B. Jeejeebhoy	101.00
Mr. K. T. Mathew	101.00
Mr. Suhrid Sarabhai	101.00
Mr. Y. R. Ghorpade	101.00
Mr. E. Hanumantha Rao	101.00
Mr. Ajit Wagh	100.00
Mr. Madukant Thacker	100.00
Dr. D. K. Lahiri Choudhury	100.00
M/s. Firdos S. Cambatta	100.00
Mr. C. Ramakrishna	100.00
Mr. J. R. Codho	100.00
Mr. D. Ranganathan	100.00
Mr. Shaik Samasul Huda	100.00
Mr. Sikandar Futehally	100.00
Mr. O. S. Fernandes	100.00
Mr. C. F. Hawilloy	100.00
Mr. David Ferguson	100.00

Total amount received during 1984	65,302.35

And also there were 107 donations which were below Rs. 100/.

For Field Studies & Scholarships:

Watanmal Bookhand Charitable Trust	15,000.00

For Photographic Exhibition:

Mr. M. Y. Ghorpade	10,000.00

We are particularly grateful to M/s. Larsen and Toubro Limited for the donation of 16000 greeting cards.

RESEARCH FUNDED BY GOVERNMENT AND GOVERNMENTAL AGENCIES

Studies on the movement and population structure of Indian Avifauna:

The project continued with bird ringing and related studies. Rajasthan government, at a meeting of the Wildlife Advisory Board, discussed the matter of granting permission for ringing at Bharatpur. But since the permit was not issued during the year, there was no ringing activity in the sanctuary.

Seasonal ringing stations were conducted at Mundanthurai and Kalakkad in Tamil Nadu, Jamnagar and Khijadia in Saurashtra, Chilka in Orissa and Harike in Punjab.

Endangered species project staff undertook ringing in Karera (M.P.) on exploratory basis.

Total number of birds ringed during the year are as follows:

Point Calimere 8538 birds of 90 species; Chilka 2414 birds of 47 species; Harike 4327 birds of 65 species; Jamnagar and Khijadia 294 birds of 26 species.

Highlights of the Recovery Data:

The following countries have reported recovery of our ringed birds:

1. E. Africa — 1 (Reeve); 2. S. Africa — 1 (Reeve); 3. China — 1 (Redcrested Pochard); 4. U.S.S.R. — 46 (Pintail, Common Teal, Gadwall, Kigeon, Common Pochard, Tufted Duck, Coot, Ruff and Reeve, Little Stint, Curlew, Sandpiper) (through Prof. Gavrilov), 2 (Little Stint, Curlew, Sandpiper).

An Ecological Study of Bird Hazards at Indian Aerodromes Work at Aerodromes:

Field study has been completed at Gwalior, Jodhpur, Trivandrum and Bangalore. Work started at Dundigul and Gorakhpur. Reports will be prepared for all these aerodromes. The remaining aerodromes are Patna, Nagpur, Kalaikunda, Calcutta, Tezpur, Chabua, Madras, Jammu, Srinagar, Adampur and Chandigarh.

The ARDB has requested us to take up Hyderabad also for study; for which we have agreed.

Banding vultures to study their movement:

The work was held up due to shortage of research hands and non-availability of numbered wing tags.

Vulture Aviary experiment at KVIC premises:

This was delayed as it took a long time to get a favourable response from the Khadi and Village Industries Commission who own the premises.

Publications:

a) The first Annual Report under Phase-2 covering Delhi, Bombay and Hindan aerodromes was produced.
b) Guide booklet on "Potential Problem Birds at Indian Aerodromes" was published for the ARDB.

Ecology of Certain Endangered Species of Wildlife and Their Habitats Great Indian Bustard:

The year 1984 saw the achievement of all the objectives of this project namely:

1. Present distribution
2. Examinations of the habitats
3. Determination of transient or resident nature of the bird
4. Determination of breeding areas and season
5. Study of the biology
6. Dispersal and seasonal movement
7. Management Plan

Future Plans:

We still have one and a half year of the project. During this period, in addition to continuing our ongoing studies, we plan to do the following studies:

a) Establishment of a field station at Rollapadu

b) Study of the movement of the banded bustards at Nanaj

c) Study of the individual behaviour of the colour-banded birds at Karera with special reference to intra-specific interaction.

d) More surveys in Gujarat, Rajasthan and Karnataka for determining the exact population of the bustards.

Second annual report has been published.

Elephant:

Extensive studies were conducted in Tirunelveli and Kanya Kumari districts. The areas covered were Thirukkuremgudi range, Nambikoil area Nadugani, Kodaikolasharmottai, Panagudi hills, Balamore Tea Estate, Keeriperai area, Sengalltheri (Kalakkadu Wildlife Sanctuary), Naiaikadu and Mundanthurai Wildlife Sanctuary. These surveys were aimed at collecting food plants and studying the feeding habits of elephants. Preliminary work was also carried on in Bandipur and Mudumalai Sanctuaries. Intensive studies at Mudumalai and Bandipur Sanctuaries have been planned for 1985.

Hydrobiological (Ecological) Research Station at Keoladeo Ghana National Park, Bharatpur:

Data was collected in various disciplines to determine factors influencing the ecosystem. New areas under study during the year were:

1. Silica content in water, 2. Biological oxygen demand in the lake, 3. Diurnal cycle of Planktons, 4. Impact of guano on the aquatic life, 5. Sarus Crane studies, 6. Raptor studies, 7. Wintering ecology of Siberian Cranes.

Cattle grazing in the park was stopped during the year and its effect on the ecology of the Sanctuary is being studied.

MEETINGS & FIELD TRIPS

January: *Slide show*: "A trip across Tibet" by Dr. Lawrence Swan, on 4th January 1984.

February: *Festival of films*: "A property in the country" and "Missing Monsoon", on 6th February. "The Great one-horned Rhinoceros" and "Round Robin", on 7th February. "The Hidden World" "The Last Roundup" and "Adventure has wings", on 8th February. "The Leopard that changed its spots" and "Operation Osprey", on 9th February. "Tiger Tiger" and "Flight for survival", on 10th February.

March: *Talk*: "Nisarg Yatra around Konkan" by Oswald Thayil, on 22nd March.

April: *Talk*: "Nandur-Madhmeshwar" by Debi Goenka & Oswald Thayil, on 12th April. *Film Show*: "A Robe of White" and "The Language of Birds", on 21, 23 & 24th April.

May: *Musical concert*: By Smt. Kishori Amonkar at Birla Matushri Sabhaghar, on 6th May.

The Society is indebted to Smt. Kishori Amonkar for generously donating her time and talent for this fund raising programme.

June: *Slide show*: "Birds of Indian Wetland" by Pakshi Mitra Mandal, Nasik, on 8th June. *Nature camp*: At Malshej Ghat, on 23rd & 24th June. *Slide show*: "Identification of common butterflies" by Meena Haribal, on 30th June.

July: *Field trip*: "Field identification of butterflies at IIT Powai Camp, *Slide show*: "Bird community structure around the world" by Dr. David L. Pearson, on 2nd July. *Nature walk*: At Borivli National Park, on 29th July.

August: *Slide show*: "A visit to Garhwal Himalayas" by Meena Haribal, on 10th August. *Nature walk*: From Forest Checknaka to Bhoot Bangla, on 12th August. *Nature camp*: At Pal Yawal (Jalgaon dist.), from 25th to 29th August.

September: *Slide show*: "Recent Measures to Save Certain South-east Asian Endangered Species" by Major Ian Grimwood, on 4th September. *Nature walk*: "Monsoon Flora" at BNHS Land, on 9th September. *Film show*: "The making of a Natural History Film", on 17th September.

October: *Film show*: Nature films sponsored by Sanctuary Magazine, on 1, 3, & 5th October. *Nature walk*: At Nag-phani & Tiger's Leap, on 13th & 14th October. *Slide show*: On butterflies by Mr. N. D. Mulla, on 17th October.

December: *Nature camp*: At Chanderi, on 2nd December. *Nature walk*: At IIT Powai, on 9th December.

REFERENCE COLLECTION

During the year 139 specimens were registered into the collections.

Birds	16
Frogs & Toads	57
Lizards	21
Snakes	5
Insects	40
	139

Interesting additions are the Spoonbilled Sandpiper and the Skink *Dasia haliana.*

During the year Mr. Humayun Abdulali continued the cataloguing of the bird collection. Part 30 of the catalogue, which covers 1141 specimens of 107 species and sub species, Nos. 1471-1571 (*Tesia cyaniventer* to *Sylvia nana nana*) in Indian Handbook and Synopsis, and 15 extra-limitals was completed in 1984.

REVENUE AND ACCOUNTS

The financial situation of the Society is a cause for concern. The year's working showed a deficit of Rs. 28,807.46.

STAFF

The Committee wishes to record its appreciation of the willing co-operation of the staff in the activities of the Society.

Regd. No. F. 244 (BOM)

BOMBAY NATURAL HISTORY SOCIETY

BOMBAY PUBLIC TRUSTS ACT, 1950
SCHEDULE VIII VIDE RULE 17(1)

BALANCE SHEET FOR THE YEAR ENDED 31 *DECEMBER*, 1984

FUNDS AND LIABILITIES		
Trust Fund or Corpus:		
Life Membership Fund (Individual):		
Balance as per last Balance Sheet	3,14,519.33	
Add: Amount received during the year	72,471.90	3,86,991.23
Corporate Life Membership Fund:		
Balance as per last Balance Sheet	1,88,161.31	
Add: Amount received during the year	12,500.00	2,00,661.31
Vice Patron Fees:		
Balance as per last Balance Sheet		42,769.00
Other Earmarked Funds:		
Created out of the income as per Schedule 'C'		26,45,750.87
Other Funds:		
As per Schedule 'A'		3,27,374.64
Liabilities:		
For unspent grants (As per Schedule 'B' (Part I & III)	12,38,778.41	
For expenses	2,16,875.59	
For Library deposit	1,350.00	
For Sundry Credit Balances	15,031.37	
For Advances for Publications (Under preparation)	3,482.61	14,75,517.98
Carried over		50,79,065.03

ASSETS		
Immovable Properties:		Nil
Investments (At appropriated value):		
Government Securities (At cost):		
3% Conversion Loan 1946/86 at the face value of Rs. 25,000/- (Market value)	25,000.00	
5½% Govt. of India Loan 2000 of the face value of Rs. 2,000/- (Market value)	2,000.00	
In Units of the face Value:		
Rs. 2,58,269.10 of the Unit Trust of India (Under re-investment plan)	2,59,519.76	
In Fixed Deposit with Maharashtra State Road Transport Corporation:	60,000.00	3,46,519.76
Motor Cars, Motor Cycles & Auto Cycles:		
Balance as per last Balance Sheet	1,535.73	
Less: Depreciation during the year	307.15	1,228.58
Furniture, Fixture & Equipment:		
Balance as per last Balance Sheet	77,843.10	
Add: Additions during the year	26,518.80	
	1,04,361.90	
Less: Depreciation during the year	13,045.24	91,316.66
Carried over		4,39,065.00

FUNDS AND LIABILITIES

Brought over		50,79,065.03
For Other Advances:		
(Amount received for & on behalf of the proposed institute)		
Balance as per last Balance Sheet	2,38,952.46	
Add: Interest credited during the year	20,000.00	
	2,58,952.46	
Less: Expenditure for & on account of the Institute incurred during the year	10,202.38	2,48,750.08
Carried over		53,27,815.11

ASSETS

Brought over			4,39,065.00
Loans (Unsecured considered good):			
To employees			6,660.00
Advances (Unsecured considered good):			
To Trustees (for expenses)		—	
To employees (for project expenses)		1,76,513.35	
To employees (for other Society's expenses)		4,058.52	
To others		6,338.00	
To Nature Education Scheme		16.547.37	
Excess of Expenditure over Income in Specific funds recoverable from future grants:			
1) Avifauna Project	19,277.63		
2) Chilka Lake Bird Ringing Project	17,506.56		
3) Dr. Salim Ali's Secretarial assistance grant	13,255.62	50,039.81	
4) *Suspense account* (considered doubtful)		28,860.15	2,82,357.20
Stocks:			
A) Publications as per inventory taken & certified by the Honorary Secretary at or below cost		7,65,917.44	
B) Safety cartridges as certified by the Honorary Secretary at cost		9,530.35	
C) i) Book of Indian Trees (at cost under preparation)		3,550.00	
ii) Book of Indian Birds (as cost under preparation)		51,475.00	8,30,472.79
Carried over			15,58,554.99

FUNDS AND LIABILITIES	
Brought over	53,27,815.11
Total	53,27,815.11

ASSETS		
Brought over		15,58,554.99
Income Outstanding:		
Interest accrued	46,517.51	
Supplies & Services	1,78,902.79	
Grant Govt. of Maharashtra for 1984-85	1,69,406.00	
Grant Govt. of India, Dept. of Science & Technology	40,000.00	4,34,826.30
Income Tax Refundable:		20,986.40
Cash & Bank Balances:		
As per Schedule 'D' (including Rs. 17,44,000/- fixed deposits, monthly income certificates)		32,95,659.66
Income & Expenditure Account:		
Excess of expenditure over income transferred from Income & Expenditure Account	21,119.76	
Less: Balance as per last Balance Sheet	3,332.00	17,787.76
Total		53,27,815.11

Sd/- A. N. D. NANAVATI
Honorary Secretary,
Bombay Natural History Society

Sd/- H. K. DIVEKAR
Honorary Treasurer,
Bombay Natural History Society

As per our report of even date
Sd/- HABIB & Co.,
Chartered Accountants.

BOMBAY, 8*th December*, 1986.

SCHEDULE 'A'

BOMBAY NATURAL HISTORY SOCIETY

SCHEDULE FORMING PART OF BALANCE SHEET AS AT 31ST DECEMBER 1984

	Name of the Fund/Grant (1)	*Balance as per last Balance Sheet* (2)	*Amount received appropriate during the year* (3)	*Interest received during the year* (4)	*Total of columns 2, 3, & 4* (5)	*Exp. on objects of the Society as shown in Income & Exp. A/c.* (6)	*Balance as at 31st December 1984 (5 minus 6)* (7)
(1)	Staff Welfare Fund	32,566.22	—	3,256.62	35,822.84	—	35,822.84
(2)	Interest on Col. Burton's Nature Conservation Fund Investment	401.03	—	300.00	701.03	639.97	61.06
(3)	Charles McCann Vertebrate Zoology Field Work Fund	45,613.64	8,700.00	4,561.36	58,875.00	1,878.15	56,996.85
(4)	Salim Ali Nature Conservation Fund for Silent Valley Expenses	11,341.97	—	—	11,341.97	—	11,341.97
(5)	Hospitality Fund Dr. Salim Ali	711.15	—	—	711.15	350.78	360.37
(6)	Projector Fund received from members	968.04	—	—	968.04	—	968.04
(7)	Scholarship Fund under Salim Ali/Loke Wan Tho Ornithological Research Fund Investment	9,103.02	—	32,113.65	41,216.67	33,890.91	7,325.76
(8)	Conservation Fund under Salim Ali Nature Conservation Fund Investment	43,774.65	—	62,111.43	1,05,886.08	25,217.75	80,668.33
(9)	Field Work Fund under Pirojsha Godrej Foundation Fund Investment	2,461.58	—	4,000.00	6,461.58	6,461.58	—
	Carried over	1,46,941.30	8,700.00	1,06,343.06	2,61,984.36	68,439.14	1,93,545.22

SCHEDULE 'A' (contd.)

Name of the Fund/Grant (1)	*Balance as per last Balance Sheet* (2)	*Amount received appropriate during the year* (3)	*Interest received during the year* (4)	*Total of columns 2, 3, & 4* (5)	*Exp. on objects of the Society as shown in Income & Exp. A/c.* (6)	*Balance as at 31st December 1984 (5 minus 6)* (7)
Brought over	1,46,941.30	8,700.00	1,06,343.06	2,61,984.36	68,439.14	1,93,545.22
(10) Field Work Fund under Sir Dorabjee Tata Trust	10,000.00	—	—	10,000.00	—	10,000.00
(11) Field Study & Scholarships and from Watanmal Boolchand Charitable Trust	—	15,000.00	—	15,000.00	—	15,000.00
(12) Photography Exhibition Fund received from Shri M. Y. Ghorpade of Sandur	—	10,000.00	—	10,000.00	—	10,000.00
(13) Plant Study Fund under Interest on Plant Study Investment	—	—	3,058.02	3,058.02	424.76	2,633.26
(14) Education & Research Fund (Created out of income for 1984)	—	96,196.16	—	96,196.16	—	96,196.16
Total	1,56,941.30	1,29,896.16	1,09,401.08	3,96,238.54	68,863.90	3,27,374.64

SCHEDULE 'B' (PART I)

BOMBAY NATURAL HISTORY SOCIETY

SCHEDULE FORMING THE PART OF BALANCE SHEET AS AT 31ST DECEMBER 1984

Name of the Grant (1)	*Balance as per last Balance Sheet* (2)	*Amount received during the year* (3)	*Unspent Balance carried over to next year* (4)	*Income for the year as credited to Income & Exp. A/c.* (5)	*Amount spent during the year* (6)	*Excess of exp. over income carried over to next year* (7)
A. (1) *Grant Govt. of Maharashtra for Establishment & Building Maintenance*:						
a) For 1983-84	34,802.46	—	—	34,802.46	34,802.46	—
b) For 1984-85	—	1,65,406.00	50,330.80	1,15,075.20	1,15,075.20	—
(2) *Grant Govt. of Maharashtra for Building Repairs*:						
For 1983-84 Contd. 1984-85	1,23,000.00	—	1,23,000.00	—	—	—
(3) *Grant Govt. of India for Building Repairs*:						
For 1980-81 Contd. 1982-83 Contd. 1983-84 Contd. 1984-85	78,447.56	—	—	78,447.56	78,447.56	—
For 1984-85	—	90,000.00	15,800.56	74,199.44	74,199.44	—
Total	2,36,250.02	2,55,406.00	1,89,131.36	3,02,524.66	3,02,524.66	—

SCHEDULE 'B' (PART II)

BOMBAY NATURAL HISTORY SOCIETY

SCHEDULE FORMING THE PART OF BALANCE SHEET AS AT 31ST DECEMBER 1984

Name of the Grant (1)	*Balance as per last Balance Sheet* (2)	*Amount received during the year* (3)	*Unspent Balance carried over to next year* (4)	*Income for the year as credited to Income & Exp. A/c.* (5)	*Amount spent during the year* (6)	*Excess of exp. over income carried over to next year* (7)
B. *Grants for Journal Publication*:						
(1) Govt. of Maharashtra for 1984-85	—	4,000.00	—	4,000.00	4,000.00	—
(2) Govt. of India, Department of Science & Technology for 1984-85	—	40,000.00	—	40,000.00	40,000.00	—
(3) Indian National Science Academy for 1984-85	—	5,000.00	—	5,000.00	5,000.00	—
Total	—	49,000.00	—	49,000.00	49,000.00	—

As per our report of even date
Sd/- HABIB & Co.,
Chartered Accountants.

SCHEDULE 'B' (PART III)

BOMBAY NATURAL HISTORY SOCIETY

SCHEDULE FORMING PART OF INCOME & EXPENDITURE & BALANCE SHEET AS AT 31ST DECEMBER 1984

Name of the Grant (1)	*Balance as per last Balance **Sheet*** (2)	*Amount received during the year* (3)	*Unspent Balance carried over to next year* (4)	*Income for the year as credited to Income & Exp. A/c.* (5)	*Amount spent during the year* (6)	*Excess of exp. over income carried over to next year* (7)
(1) Grant Govt. of India, Ministry of Defence Aeronautics Research & Development Board for Ecological Study of Bird Hazards at Indian Aerodromes	11,66,853.07	—	1,00,090.93	10,66,762.14	10,66,762.14	—
(2) *Grants* from US Department of the Interior Fish & Wildlife Service — National Park Service:						
i) Studies on the movement & population structure of Indian Avifauna	27,603.04	4,59,762.72	—	4,87,365.76	5,06,643.39	19,277.63
ii) Hydrobiological (Ecological) Research Station at Keoladeo Ghana Sanctuary, Bharatpur	4,19,192.09	3,53,400.00	1,64,519.97	6,08,072.12	6,08,072.12	—
iii) Study of Ecology of Certain Endangered Species of Wildlife & Their Habitats	2,66,976.14	3,29,811.00	1,58,332.04	4,38,455.10	4,38,455.10	—
iv) Study of Lesser Bustard (Florican) *Sypheotides indica* and the Bengal Florican *Eupoditis bengalensis*	—	4,91,560.00	4,42,059.34	49,500.66	49,500.66	—
(3) Grant from Chief Wildlife Warden, Chandigarh Punjab for Bird Ringing Project at Harike	44,980.16	50,800.00	41,115.11	54,665.05	54,665.05	—
(4) Grant from Chief Wildlife Warden, Bhubaneswar, Orissa for Bird Ringing Project at Chilka	—	—	—	—	17,506.56	17,506.56
Carried over	19,25,604.50	16,85,333.72	90,61,117.39	27,04,820.83	27,41,605.02	36,784.19

SCHEDULE 'B' (PART III) (contd.)

Name of the Grant (1)	Balance as per last Balance Sheet (2)	Amount received during the year (3)	Unspent Balance carried over to next year (4)	Income for the year as credited to Income & Exp. A/c. (5)	Amount spent during the year (6)	Excess of exp. over income carried over to next year (7)
Brought over	19,25,604.50	16,85,333.72	90,61,117.39	27,04,820.83	27,41,605.02	36,784.19
(5) Grant, Govt. of India, Dept. of Environment for the expenses on Secretarial Assistance to Dr. Salim Ali for environmental Research Programme for processing the Archival material	—	—	—	—	12,157.00	12,157.00
(6) Grant, Govt. of India, Dept. of Science and Technology for Bird Data Analysing Study for 1980-81 Contd. to 1984-85	11,413.56	—	11,413.56	—	—	—
(7) Grants, Govt. of India, Dept. of Science & Technology for the publication of:						
i) A Century of Natural History	—	1,37,000.00	—	1,37,000.00	1,37,000.00	—
ii) Book of Indian Reptiles	—	1,30,000	—	1,30,000.00	1,30,000.00	—
iii) Encyclopedia of Indian Natural History	—	2,54,000.00	1,02,351.20	1,51,648.80	1,51,648.80	—
(8) Grant, Govt. of India, Dept. of Culture for publishing the Centenary Seminar papers of the Society	—	30,000.00	29,764.90	235.10	235.10	—
Total	19,37,018.06	22,36,333.72	10,49,647.05	31,23,704.73	31,72,645.92	48,941.19

As per our report of even date
Sd/- HABIB & Co.,
Chartered Accountants.

SCHEDULE 'C'

BOMBAY NATURAL HISTORY SOCIETY

SCHEDULE FORMING THE PART OF BALANCE SHEET AS AT 31ST DECEMBER 1984

	Name of the Fund Grant (1)	*Balance as per last Balance Sheet* (2)	*Received during the year* (3)	*Total of column 2 & 3* (4)	*Transferred to Income & Exp. A/c. as shown in the Income & Exp. A/c.* (5)	*Balance as at 31 December 1984 (4 minus 5)* (6)
(1)	Fixed Assets Fund	56,331.01	—	56,331.01	13,352.39	42,978.62
(2)	Building Fund	1,03,227.68	10,000.00 (Interest)	1,13,227.68	10,000.00	1,03,227.68
(3)	General Reserve Fund	37,952.71	—	37,952.71	—	37,952.71
(4)	Provision for Depreciation on Investment	9,266.10	—	9,266.10	—	9,266.10
(5)	Provision for Capital Losses	15,025.23	—	15,025.23	—	15,025.23
(6)	Publication Fund	8,81,910.46	2,406.90	8,84,317.36	—	8,84,317.36
(7)	Govt. of India, Dept. of Science & Technology Publication Fund i) Sale proceeds of A Century of Natural History Rs. 42,552.95 ii) Book of Indian Reptiles Rs. 30,479.63	—	73,032.58	73,032.58	—	73,032.58
(8)	Salim Ali Loke Wan Tho Ornithological Research Fund	3,21,136.52	—	3,21,136.52	—	3,21,136.52
(9)	Col. Burton's Nature Conservation Fund	3,000.00	—	3,000.00	—	3,000.00
(10)	Sir Pirojsha Godrej Foundation Field Work Fund	40,000.00	—	40,000.00	—	40,000.00
	Carried over	14,67,849.71	85,439.48	15,53,289.19	23,352.39	15,29,936.80

SCHEDULE 'C' (Contd.)

	Name of the Fund/Grant (1)	Balance as per last Balance Sheet (2)	Received during the year (3)	Total of column 2 & 3 (4)	Transferred to Income & Exp. A/c. as shown in the Income & Exp. A/c. (5)	Balance as at 31 December 1984 (4 minus 5) (6)
	Brought over	14,67,849.71	85,439.48	15,53,289.19	23,352.39	15,29,936.80
(11)	Salim Ali Nature Conservation Fund	6,18,124.80	11,218.51	6,29,343.31	—	6,29,343.31
(12)	Plant Study Fund	25,000.00	65,302.37	90,302.37	—	90,302.37
(13)	Staff Gratuity Fund	2,33,480.00	23,348.00 (Interest)	2,56,348.00	—	2,56,828.00
(14)	Centenary Celebrations Fund	1,06,254.65	1,052.69	1,07,307.34	17,966.95	89,340.39
(15)	Hornbill Newsletter Fund	50,000.00	5,000.00 (Interest)	55,000.00	5,000.00	50,000.00
	Total	25,00,709.16	1,91,361.05	26,92,070.21	46,319.34	26,45,750.87

SCHEDULE 'D'

BOMBAY NATURAL HISTORY SOCIETY

SCHEDULE FORMING THE PART OF BALANCE SHEET AS AT 31ST *DECEMBER* 1984

CASH AND BANK BALANCES	Rs. Ps.	Rs. Ps.
A) *In Current Account with:*		
i) Grindlays Bank, p l c, M. G. Road, Bombay 400 023	3,88,801.21	
ii) Grindlays Bank p l c, London (£ 1155.58 @ Rs. 14.55)	16,813.68	
iii) Chartered Bank, M. G. Road, Bombay 400 023	2,42,427.87	6,48,042.76
In Savings Account with:		
iv) Grindlays Bank p l c, M. G. Road, Bombay 400 023	1,25,606.73	
v) Bank of India, Museum Savings Branch M. G. Road, Bombay 400 023	14,676.52	
vi) Bank of Baroda, University Branch, M. G. Road, Bombay 400 023	2,82,909.00	
vii) Corporation Bank, Dalal Street, Bombay 400 023	4,80,424.65	9,03,616.90
B) *In Fixed Deposits with:*		
i) Bank of India, M. G. Road, Bombay 400 023	1,14,000.00	
ii) Chartered Bank, –do–	1,00,000.00	
iii) Bank of Baroda, –do–	1,00,000.00	
iv) Corporation Bank, Dalal Street, Bombay 400 023	5,00,000.00	
v) Grindlays Bank p l c, M. G. Road, Bombay 400 023	1,55,000.00	
C) *In Monthly Certificate with:*		
Bank of India, M. G. Road, Bombay 400 023	7,75,000.00	17,44,000.00
*Total		32,95,659.66

* *includes earmarked against the following funds:* (p. 717)

Carried over

SCHEDULE 'D' (contd.)

	Brought over	
a)	Dr. Salim Ali-Loke Wan Tho Ornithological Research Fund	Rs. 3,21,136/–
b)	Dr. Salim Ali Nature Conservation Fund	Rs. 6,29,343/–
c)	Pirojsha Godrej Foundation Fund	Rs. 40,000/–
d)	Charles McCann Vertebrate Zoology Field Work Fund	Rs. 56,996/–
e)	Building Maintenance Fund	Rs. 1,00,000/–
f)	Staff Gratuity Fund	Rs. 2,56,828/–
g)	Hornbill Newsletter Fund	Rs. 50,000/–
h)	Staff Welfare Fund	Rs. 35,822/–
i)	Col. Burton's Nature Conservation Fund	Rs. 3,000/–
j)	Proposed Institute	Rs. 2,00,000/–
k)	Plant Study Fund	Rs. 50,000/–
		Rs. 17,43,125/–

Regd. No. F. 244 (BOM)

BOMBAY NATURAL HISTORY SOCIETY

BOMBAY PUBLIC TRUSTS ACT, 1950
SCHEDULE IX VIDE RULE 17(1)

INCOME AND EXPENDITURE ACCOUNT FOR THE YEAR ENDED 31ST DECEMBER 1984

EXPENDITURE

To *Expenses in Respect of Properties*:		
„ *Rates & taxes*: Met out of grant, Govt. of Maharashtra 1984-85		4,827.00
„ *Repairs & Maintenance*:		
a) Met out of grant Govt. of India, Dept. of Sc. & Technology 1980-81 contd. till 1984-85	78,447.56	
b) Met out of grant Govt. of India, Dept. of Sc. & Technology for 1984-85	74,199.44	1,52,647.00
„ *Insurance* (on building): Met out of grant Govt. of Maharashtra for 1983-84		323.00
„ *Other Contingency Expenses*: Met out of grant Govt. of Maharashtra		
for 1983-84	126.61	
for 1984-85	3,173.00	
(As per Schedule B Part I)		
Carried over	3,299.61	1,57,797.00

INCOME

By *Rent* (Accrued & Realised):		Nil
„ *Interest* (Accrued):		
On Securities	860.00	
On fixed deposits & bank account (including Rs. 1,67,749.08 on earmarked funds)	2,17,243.34	2,18,103.34
„ *Dividend*:		30,583.53
„ *Donations* (in cash or in kind):		
For specific funds:		
Centenary celebrations	1,052.69	
Photographic Exhibition	10,000.00	
Life membership	500.00	
Charles McCann Vertebrate Zoology Field Work Fund	8,700.00	
Sálim Ali Nature Conservation Fund	11,218.51	
Plant Study Fund (from members & others)	65,302.37	
Watanmal Boolchand Charitable Trust towards Scholarship & Field Study	15,000.00	
	1,11,773.57	
„ *Other General Donations*:	7,495.33	
Life Membership Fees (individual)	55,110.00	
Centenary Lifemembership Fees	16,861.90	
Corporate Lifemembership Fees	12,500.00	2,03,740.80
„ *Grants* (As per Schedule B Part I, II, & III):		34,75,229.39
Carried over		39,27,657.06

EXPENDITURE			
Brought over		1,57,797.00	
To *Other Contingency Expenses* (Contd.):			
Brought over	3,299.61		
„ *Other Expenses*:			
Contingency expenses, electricity charges etc. including Rs. 10,000/- charged to Building Fund (As per contra)	17,894.94	21,194.55	1,78,991.55
„ *Establishment Expenses*:			
A) Salaries including DA etc. met out of grant Govt. of Maharashtra for 1983-84	34,352.85		
for 1984-85	1,07,075.20	1,41,428.05	
(as per Schedule B Part I)			
B) Salaries including DA etc. (other than above)		3,59,385.40	
Society's contribution to Staff Provident Fund		14,088.00	
Postages		16,630.40	
Printing & Stationery		35,023.35	
Advertisement		5,496.00	
Telephone Rental & Call charges		7,822.65	
Meeting expenses		1,399.15	
Conveyance & Travelling expenses (local)		4,513.00	
Carried over		5,85,786.00	1,78,991.55

INCOME		
Brought over		39,27,657.06
By *Income from Subscriptions & Entrance Fees*:		
Membership Subscriptions (individual)	96,326.53	
Corporate membership subscriptions	35,471.13	
Student membership subscriptions	2,635.00	
Subscription to Journal (non-members)	31,514.47	
Entrance fees	14,010.00	1,79,957.13
„ *Income from Publications*:		
Journal Sales	3,203.00	
Glimpses of Nature Booklet	2,406.90	
Sale proceeds of Book of Indian Reptiles	30,479.63	
Sale proceeds of A Century of Natural History	42,552.95	
Book of Indian Birds	31,092.50	
Book of Indian Animals	19,796.00	
Some Beautiful Indian Trees	3,556.00	
Some Beautiful Indian Ciimbers & Shrubs	4,813.40	
Identification of Poisonous Snake Chart	180.00	
Synopsis of the Birds of India & Pakistan	2,359.00	
Grasses of Western India	1,355.00	
Butterflies of Indian Region	1,896.00	
Pictorial Guide to the Birds of Indian Subcontinent	1,789.70	
Other publications	8,281.01	
Nature calendars	34,306.98	
Greeting cards	96,196.16	
	2,84,264.23	
Less: Packing & forwarding charges	89.39	2,84,174.84
Carried over		43,91,789.03

	EXPENDITURE		
	Brought over		1,78,991.55
To	*Establishment Expenses* (Contd.):	5,85,786.00	
	Bank charges	1,566.72	
	Wages (local labour)	150.00	
	Medical expenses to staff members	7,596.80	
	Leave travel expenses to staff members	9,184.80	6,04,284.32
,,	*Audit Fees*:		1,000.00
,,	*Amounts Written off*:		
	Bad debts		1,926.58
,,	*Miscellaneous Expenses*:		
	General Contingency Expenses	5,534.65	
	Insurance premium	507.00	
	Exchange fluctuation	1,057.35	
	Repairs to furniture & equipments	1,290.10	
	Garden maintenance expenses	1,160.00	
	Professional fees	1,000.00	
	Society's membership fees	1,647.00	
	Booklet on Pani & Vihiri	4,550.00	
	Unforeseen expenses	610.00	17,356.10
,,	*Depreciation*:		
	On furniture & equipments	13,045.24	
	On motor cars, motor cycle & auto cycle (as per contra)	307.15	13,352.39
,,	*Centenary Celebrations*:		
	Salary to seminar staff	5,177.40	
	Audio visual	1,365.00	
	Contingency expenses	2,910.00	
	Photographic exhibition expenses	1,039.55	
	Postage	75.00	
	Centenary brochure met out of Centenary Celebration Fund (as per contra)	7,400.00	17,966.95
	Carried over		8,34,877.89

	INCOME		
	Brought over		43,91,789.03
By	*Miscellaneous Income*:		
	Miscellaneous receipts	5,668.99	
	Nett receipts from cultural programme organised as a part of Centenary Celebrations	46,565.55	
	Fees for the use of transparencies	13,400.00	
	Royalty on Journal reproduction	4,953.96	70,588.50
,,	*Administrative Fees*:		
	For handling the Greeting Card sales account	10,688.46	
	For handling A Century of Natural History publication sales	5,097.55	
	For handling the Book of Indian Reptiles publication sales	4,267.87	
	For handling project funds	2,91,401.32	
	For handling other earmarked funds	10,466.71	3,21,921.91
	Receipts from members for Chopta Nature camp		31,818.00
,,	*Amount Transferred from Specific Funds*:		
	From Building Fund towards expenditure on Building Maintenance	10,000.00	
	From Fixed Assets Fund towards depreciation	13,352.39	
	From Hornbill Newsletter Fund towards expenditure on Hornbill Newsletter	5,000.00	
	Carried over	28,352.39	48,16,117.44

EXPENDITURE			
Brought over			8,34,877.89
To *Amounts Transferred to Reserve or Specific Funds*:			
Donation towards specific funds transferred to relevant account in the Balance Sheet		1,11,773.57	
Life membership fees transferred to Life membership Fund in the Balance Sheet		71,971.90	
Corporate Life membership fees transferred to Corporate Life membership Fund in the Balance Sheet		12,500.00	
Sale proceeds of Glimpses of Nature booklet transferred to Publication Fund in the Balance Sheet		2,406.90	
Sale proceeds of publications:			
i) A Century of Natural History ..	42,552.95		
ii) Book of Indian Reptiles	30,479.63	73,032.58	
Interest on Fixed Deposits transferred to respective funds in the Balance Sheet		1,67,749.08	4,39,434.03
,, *Provisions/Appropriations to Specific Fund*:			
Provision for Research & Education			96,196.16
,, *Expenses on Objects of the Trust*:			
Educational: met from			
i) respective funds as per Schedule 'A'		68,863.90	
ii) Expenses met out of grants on objects of the Trust As per Schedule 'B'		31,72,645.92	32,41,509.82
Carried over			46,12,017.90

INCOME		
Brought over		48,16,117.44
By *Amount transferred from specific funds*:	28,352.39	
From Centenary Celebration Fund Towards expenditure on Centenary Celebrations	17,966.95	
From various specific funds towards expenses on objects (as per contra vide Schedule 'A')	68,863.90	1,15,183.24
Excess of expenditure over income against specific grants carried over to next year (for recoupment from future grants as per Schedule Part B III)		48,941.19
Excess of expenditure over income transferred to Balance Sheet		21,119.76
Carried over		50,01,361.63

EXPENDITURE				INCOME	
Brought over			46,12,017.90	Brought over	50,01,361.63
To *Expenses on objects* (other than those met out of specific funds/ grants):					
i) For publishing the Journal of the Society (includes Rs. 49,000 met from specific grants as shown in Schedule 'B' Part II)		2,62,314.75			
ii) For publishing Hornbill Newsletter including Rs. 5,000/- charged to Hornbill Newsletter Fund (As per contra)		59,735.06			
,, *Library Account*:					
Subscription to other Societies	1,974.74				
Purchase of books	12,984.85				
Book binding & other library expenses	2,664.00	17,623.59			
,, *Field Programme & Other Field Study expenses & members activities*:					
Chopta Nature Camp	29,767.55				
Other local field study expenses	4,289.41				
Members activity expenses	5,927.07	39,984.03			
,, *Maintenance of Reference Collections*:		9,686.30	3,89,343.73		
Total			50,01,361.63	Total	50,01,361.63

Sd/- A. N. D. NANAVATI
Honorary Secretary,
Bombay Natural History Society

Sd/- H. K. DIVEKAR
Honorary Treasurer,
Bombay Natural History Society

As per our report of even date
Sd/- HABIB & CO.,
Chartered Accountants.

BOMBAY, 8*th December*, 1986.

BOMBAY NATURAL HISTORY SOCIETY
NATURE EDUCATION SCHEME
RECEIPTS AND PAYMENTS ACCOUNT FOR THE YEAR ENDED 31*ST DECEMBER*, 1984

RECEIPTS			PAYMENTS		
To *Balances as at* 1*st January* 1984			By Refund of Advance to Bombay Natural History Society		6,877.57
1 With Grindlays Bank p l c, Bombay on current account	1,151.49		„ Salary (Nature Education Organiser)		21,505.75
2 With Nature Education Organiser	200.00	1,351.49	„ Printing & Stationery Account		425.50
„ *Grants*:			„ General Charges Account		6,174.93
Govt. of Maharashtra for the year 1984-85		21,796.20	„ Postage Account		392.75
„ *Donations Account*:		500.00	„ *Balance as at* 31*st December* 1984		
„ *Sale of Nature Study Booklets*:		175.40	1) With Grindlays Bank p l c, Bombay on Current Account	4,793.96	
Advance from Bombay Natural History Society, Bombay		16,547.37	2) Cash on hand with Nature Education Organiser	200.00	4,993.96
Total		40,370.46	Total		40,370.46

Sd/- A. N. D. NANAVATI
Honorary Secretary,
Bombay Natural History Society

Sd/- H. K. DIVEKAR
Honorary Treasurer,
Bombay Natural History Society

As per our report of even date
Sd/- HABIB & Co.,
Chartered Accountants.

BOMBAY, 8*th December*, 1986.

BOMBAY NATURAL HISTORY SOCIETY

THE ANNUAL GENERAL MEETING OF THE BOMBAY NATURAL HISTORY SOCIETY WAS HELD ON TUESDAY, 31ST DECEMBER 1985, AT HORNBILL HOUSE AT 6.00 P.M. WHEN THE FOLLOWING MEMBERS WERE PRESENT:

1. Mr. Humayun Abdulali
2. Mr. M. R. Almeida
3. Mr. M. K. Mistry
4. Mr. J. C. Daniel
5. Mr. A. T. Faria
6. Mr. Archie D'Souza
7. Dr. A. N. D. Nanavati
8. Mr. Nigam R. Pandya
9. Prof. P. V. Bole
10. Dr. C. V. Kurkarni (in the chair)
11. Mr. A. G. Newalkar
12. Mr. S. A. Hussain
13. Mr. H. K. Divekar
14. Mr. K. Naoroji
15. Dr. Robert B. Grubh
16. Mr. Sarosh Bana
17. Dr. V. S. Vijayan
18. Mr. Shyam Chainani
19. Mrs. P. Mukherjee
20. Ms. Meena Haribal
21. Mr. Nitin Jamdar
22. Mr. Virendra Kumar Seth
23. Mr. D. P. Banerjee
24. Mr. S. K. Tadvi
25. Mr. Susheel Borkar
26. Mr. G. S. Malwankar
27. Ms. Heta Pandit
28. Mr. Debi Goenka
29. Mr. Kiran Srivastava
30. Mr. Sunjoy Monga

The Honorary Secretary, Dr. A. N. D. Nanavati, requested Dr. C. V. Kurkarni, Vice President of the Society to conduct the meeting.

1. The Honorary Secretary hoped that members had collected the cyclostyled copies of the report for 1984, and it could be taken as read.

In his supplementary report, covering 1985, he drew attention to the salient features such as recognition of Prof. P. V. Bole and Mr. M. R. Almeida for guiding post graduate students in Plant Study, donation of a bus by Telco, a donation of Rs. 25,000 for the publication of Hornbill by Seth Purshottamdas Thakurdas Devaliba Trust and a donation of Rs. 50,000 for Plant Study Fund by United Phosphorus Pvt. Ltd. As regards activities under the Society's field projects, he advised that the reports of these projects are under preparation.

The report was then discussed. Mr. Shyam Chainani requested the Chairman to inform the General Body about the offer of land to the Society by the Karnataka Govt. for setting up a Tropical Research Centre and requested him to explain the steps taken by the Society and if the offer of the Karnataka Government has been accepted or rejected. The Honorary Secretary explained to the General Body that the offer of the Karnataka Govt. had been accepted in principle. He stated that our proposal for setting up a field research station at Goregaon had not yet been finalised. Any peripheral station would have to be planned after the form of the Centre for ornithology is decided. Hence the matter is kept pending. However, the offer of the Karnataka Govt. stands open until we reply and tell them of our intentions. Mr. Chainani suggested that we should not lose this opportunity of getting land from the Karnataka Govt. and every effort should be made to set up the Tropical Forest Research Centre.

Dr. Grubh stated that we should not necessarily wait for the finalisation of the Centre proposal but that land must be cleared for the Society as today's government may change and the offer of the land to the Society may be lost.

Mr. Abdulali stated that it was not brought to the Executive Committee's notice that such a proposal had been made to the Karnataka Govt. and it was done without the Executive Committee's authorisation.

The Curator explained to the General Body that this offer was conveyed through Mr. Hussain to the Society when he was in Bangalore by the Chief Minister of Karnataka. No proposal was made by the Society.

Mr. Hussain stated that when he was in Bangalore he had the opportunity to meet the Chief Minister of Karnataka through the Secretary to Govt. of Karnataka (Forests) and in the discussion the Minister had offered the land for the Society to set up a Tropical Forest Research Centre. The offer had been immediately conveyed to the Society.

Mr. Abdulali stated that despite his objection to the wrong information given in Dr. Sugathan's article on the Birds of Point Calimere it was published by the Society. He also stated that his frog report which was submitted for publication in the Journal was kept pending for six years.

Mr. Hussain emphasised that there was nothing wrong in the article published by Dr. Sugathan. The controversy had started on the identification of a bird on which Mr. Abdulali differed though he had not seen the bird himself. The Society had published the article along with Mr. Abdulali's comments as well as Mr. Hussain's clarification on the points raised by Mr. Abdulali. There was nothing wrong in this system.

The Curator stated that Mr. Abdulali did not submit his frog report for publication in the Journal six years back as claimed by him. The fact was that he had submitted his report to the ICAR, who were funding the project, six years ago and the article was not sent to the Society for publication then.

Mr. Goenka asked for details of the date of submission of the article for publication, on which the Curator mentioned that he could not be specific but the article was not submitted for publication more than two years ago. He assured that he will let the members know the details. (see letter from Curator, circulated to members).

Thereafter Mr. H. K. Divekar proposed acceptance of the report and Mr. Naoroji seconded it. The report was adopted by the meeting.

2. The Chairman advised that since the auditor's report and the audited statement of accounts & balance sheet were not ready due to the auditor being out of station this item required to be postponed.

Mr. Debi Goenka wanted to know why the audited statement of accounts and the auditor's report was not ready and when the accounts will be ready. The Chairman stated that accounts were ready but the auditor, not being accessible, having gone out of station, his report was not available. The report would now be available within two week's time.

The Honorary Secretary stated that certain persons had written to the Auditors conveying numerous baseless accusations about use of Society's funds. To protect himself in this situation, the auditor was compelled to go through every item and every voucher in detail. This took time.

Mr. H. K. Divekar Honorary Treasurer, advised that the Society's accounting period should be changed to April to March so as to be in line with the Government's accounting year, and auditing should be started as early as possible. Several suggestions were made. Finally the Chairman stated that Honorary Treasurer should make every possible effort to complete the audit and prepare the statement of accounts well in time and positively before end of June each year.

Mr. Nitin Jamdar wanted to know if the meeting was adjourned for consideration of accounts, whether any other matters could be discussed. To this the Chairman advised that this could be done under the item 'Any other business with the permission of the Chair'.

Mr. Debi Goenka wanted to know about the outcome of the enquiry conducted by the Enquiry Committee formed for the purpose of looking into the matter of defalcation of project money at Bharatpur and whether any report had been prepared and what progress had been made regarding the recovery of the amount.

The Curator advised that the matter is pending with the Police, and the report is yet to be submitted.

The Honorary Treasurer stated that after we have received the auditor's report we can discuss this matter.

Mr. Goenka also wished to see the report submitted by the Project Scientist before the adjourned meeting commences.

3. The Chairman stated that since the auditor's report and the audited statement of accounts were not available, consideration of this matter be postponed for the adjourned meeting.

4. *Election of the Committee for the year* 1985-86

The consideration of this item was postponed for the adjourned meeting since nominations from the members were not received due to lack of time available to them. The despatch of the notice was delayed due to the accounts and hence it was not possible for the office to give sufficient time to the members to enable them to send nominations for the Executive Committee. The Chairman proposed that this item also be adjourned. At the adjourned meeting, even when held in 1986, all members eligible to attend the present meeting would automatically remain eligible to attend and vote, i.e. all members paid up for 1985.

The Honorary Secretary proposed to hold the adjourned meeting on the 31st of January 1986 at 6.00 p.m.

5. Mr. Nitin Jamdar stated that the Society's name had been degraded due to the non-cooperation by the Society. He reported the instance of the letter from Friends of Birds, Nasik who had requested a list of members of the Society, to which the Society had refused to comply.

Mr. Abdulali stated that M/s. Natraj Publishers were allowed to have a copy of members list and also to send circulars on the Society's letterhead. He wished to know as to who is paying for the expenditure on this account.

The Curator explained that M/s. Natraj Publishers were sending the circular themselves and all stationery was at their cost. The list was provided to them as they were corporate members, and as they were giving discounts to the Society's members on natural history publications.

In this context Ms Meena Haribal stated that the Society should make available list of members to any member of the Society who wishes to obtain one on payment, if necessary. The Chairman advised that the list of members are made available to members on a nominal charge.

Mrs. Phillippa Mukherjee stated that the publications of the Society should be publicised widely and a brochure should be prepared to give publicity to this effect. The Honorary Secretary informed that it would be good idea to bring out a brochure illustrating the natural history publications by the Society presently does not have. However, the the Chairman assured that efforts will be made to prepare a brochure.

Mr. Archie D'Souza suggested that the Society's Hornbill Newsletter should be put on sale to bring revenue for the Society and the Govt. should be asked to provide subsidised paper for its publication. Chairman agreed that this could be examined.

Mr. Debi Goenka wanted to know about the progress made on the Centenary Seminar Proceedings. The Curator advised that progress has not been rapid as he had only one person working on this. He hoped to bring out the proceedings next year.

The meeting terminated with a vote of thanks to the Chair.

THE ADJOURNED ANNUAL GENERAL MEETING OF THE BOMBAY NATURAL HISTORY SOCIETY TO CONSIDER ACCOUNTS AS ON 31ST DECEMBER 1985 WAS HELD AT HORNBILL HOUSE, AT 6.00 P.M. ON 31ST JANUARY, 1986, WHEN THE FOLLOWING WERE PRESENT:

1. Mr. Debi Goenka
2. Ms. Heta Pandit
3. Shri Jayesh Y. Vadhavkar
4. Mr. S. K. Tyagi
5. Mr. N. D. Mulla
6. Mr. Sumant R. Shah
7. Dr. M. R. Almeida
8. Dr. P. J. Deoras
9. Mr. Shyam Chainani
10. Mr. Nitin N. Jamdar
11. Mr. Suresh G. Bhatkal
12. Mr. Humayun Abdulali
13. Mr. N. D. Sethna
14. Mr. Sunil R. Zaveri
15. Dr. Robert B. Grubh
16. Mr. Goutam Narayan
17. Mr. Nigam R. Pandya
18. Mr. Anthony G. T. Carter
19. Mr. Vasant N. Raiji
20. Mr. Vasant Gandhi
21. Mr. Archibold T. Faria
22. Mr. Archie D'Souza
23. Mr. Bansi Mehta
24. Dr. (Mrs.) Saraswati Unnithan
25. Mr. Ranjit Manakadan
26. Ms. Arati A. Kaikini
27. Mr. G. B. Nadkarni
28. Prof. P. V. Bole (in the chair)
29. Dr. A. N. D. Nanavati,
30. Mr. J. C. Daniel
31. Mr. H. K. Divekar
32. Dr. C. V. Kulkarni
33. Mr. Ulhas Rane
34. Mr. M. D. Agharkar
35. Ms. Uma Roy Choudhury
36. Mr. Sam N. Mistry
37. Dr. Usha Shah
38. Mrs. D. S. Variava
39. Mr. J. P. Irani
40. Mr. Sarosh Bana
41. Mr. Sunjoy Monga
42. Mr. Premchand T. Dabrai
43. Mr. Deb Priya Bannerjee
44. Ms. Lima Rosalind
45. Ms. Meena H. Haribal
46. Commd. Hotan Panthakee
47. Mr. Jayant A. Shah
48. Mr. Cyrus J. Guzder
49. Shri N. Vaidyanathan
50. Dr. A. K. Joshee
51. Mr. Sorab D. N. Gandhi
52. Dr. S. H. Dandekar
53. Mr. Anand Khatau
54. Mr. Ranvir Singh
55. Mr. Sharad A. Ruparel
56. Commander GVK Unnithan
57. Mr. Chandrakanth G. Wakankar
58. Mr. Parvish Pandya
59. Mr. Sudhir R. Paradkar
60. Mr. S. A. Hussain
61. Mr. Kiran Srivastava
62. Mr. A. L. Hegde
63. Mr. Dinshaw J. Panday

In the absence of the President who was out of town, Mr. D. J. Panday proposed Prof. P. V. Bole Vice President to the Chair. The proposal was seconded by Dr. A. N. D. Nanavati.

At the outset Prof. P. V. Bole advised members of the demise of M. K. Dharmakumarsinhji of Bhavnagar, a long-standing and valued life member of the Society. Members observed a minute's silence, all standing, as mark of respect to the memory of the deceased.

Dr. P. J. Deoras referred to a press note concerning Dr. Sálim Ali's resignation as President of the Bombay Natural History Society, and asked whether it has been accepted. He was told that the Executive Committee of the Society has not yet taken a decision.

Agenda item 1. Statement of Accounts for the year 1984.

The Honorary Treasurer advised that there was an unfortunate delay in auditing of the accounts as the auditors were busy owing to other preoccupations.

The Honorary Treasurer stated that there were some plus as well as minus points in the Balance Sheet. He pointed out that the Society has created out of the income for 1984 an Education and Research Fund amounting to Rs. 96,196.16. The minus point was the deficit of Rs. 21,119.76 which is the excess of expenditure over income.

The Auditor's report was then considered. The Honorary Treasurer drew attention to the defalcation of Rs. 27,860.15 in the accounts of the Hydrobiology Studies Project at Bharatpur.

On Dr. P. J. Deoras enquiring whether a report has been filed with the Police, Mr. M. D. Agharkar gave a resume of the incident, and the steps taken for the recovery of the amount. Briefly, the defalcation was by Narasimha Raju Pakalapaty, Account/Administrative Assistant in the Bharatpur Centre who had absconded with amounts drawn from the bank towards payment of salaries not disbursed but kept overnight in a steel cupboard. The key unfortunately had been left with Narasimha Raju Pakalapaty by the Research Biologist, Shri Natarajan, who was in charge in the absence of the Project Scientist on leave. The complaint lodged with the Police has not produced results so far, and the last intimation from the Police received in October 1985 is that investigations are in progress, and that Raju has not yet been traced. Mr. Natarajan went on home leave on the plea that his father was seriously sick, and subsequently resigned from his post on 4.4.1985.

Mr. Sumant Shah enquired about steps being taken to prevent recurrences in the future, and suggested that persons handling cash should be insured. The Honorary Treasurer replied that the Society investigated the possibility of insuring the staff under fidelity cover. However, such cover is available only to permanently employed staff. The Society's Project Staff, except the Project scientists, being temporary this facility of Fidelity cover was not available.

Mr. Debi Goenka drew attention to Rule No. 63 of the Society requiring employees to provide a surety as a condition of appointment on the staff. The Honorary Treasurer informed members that though such a rule exists in the book, it has not been operative during the 100 years of the Society's existence, and it was felt unnecessary to invoke the same in the future. Mr. N. D. Mulla felt that surety was necessary and should be asked from the Society's staff. Mrs. D. S. Variava felt that: (1) surety could not be asked from staff now long employed with the Society; (2) a new temporary appointed may not be in a position to furnish such a surety; and (3) the only thing that could be done is to see that there is no recurrence of such acts in the future by being careful about who handles cash.

Mr. Shyam Chainani suggested that Rule 63 be scrapped, and some other measure be taken to ensure safety of the cash at the Projects.

The Honorary Secretary pointed out that among measures taken to prevent recurrence, monthly salaries to the staff are now being posted to the employees individually by demand drafts made out for payee's account. All permanent staff handling cash are now covered by Fidelity Insurance.

In reply to Mr. Nitin Jamdar's query if the defalcated amount would be written off, the Chairman replied that the Society is awaiting the report from the Police.

Mr. Humayun Abdulali stated that he was not satisfied with the disbursal of the amounts received from the Tata Press for a Desk Diary for 1985 for which he had provided expert advice. Two cheques had been received — one as honorarium for his work which he asked the Society to credit to Charles McCann Research Fund, and the other for payment to the photographers. His complaint was that the Honorary Secretary had not accepted his suggestion that the photographers be paid only at the rate of Rs. 500/- per picture, and the balance kept for the Society.

The Honorary Secretary replied that he had paid the photographers the full amount of Rs. 750/- as Mr. Abdulali had not provided copies of written agreement with the photographers, without which he had no authority to dispose of their fees.

Mr. Ulhas Rane, one of the photographers involved, pointed out that Mr. Humayun Abdulali had no authority to decide what the photographers should receive by way of payment for pictures they had given to Tatas.

Mr. N. D. Mulla stated that though the Auditors had accepted the accounts of the Chopta Camp organized by the Society in the Centenary year, he was unhappy with the expenditure incurred where large amounts had been spent without proper supporting vouchers but had been accepted on the basis of signed statements by the staff involved in organizing the camp. He particularly drew attention to expenditure on transport. He felt that overheads charged to camp expenses were excessive.

Mr. Sumant Shah felt that the expenses were high because the camp catered to members who were not prepared to rough it out, and required certain facilities. Thus the expenses may have been a little on the higher side. Arising out of this discussion it was felt necessary that suitable voucher forms may be prepared and supplied to staff for giving details of expenses.

Members put forth various views on controlling expenses, and it was felt that members who were willing to rough it out if it meant less cost should not be overlooked as students and younger members who required to be shown the gift of nature can then be catered to. The consensus of the meeting was that there should be two types of camps organised for members.

Mr. Raiji expressed the opinion that some of the members appeared to be unduly agitated over the defalcation and administrative expenses and since the Auditors have expressed opinion where necessary there was no need for the members to be unnecessarily perturbed.

The proposal that in future the Auditors' Report should be made available with the accounts of the Annual General Meeting was accepted.

The accounts were then put to vote and were accepted, 23 voting for, and 11 against.

Appointment of Auditors: Messrs Habib & Co., Auditors, were reappointed for the ensuing year.

Agenda item 2. The Executive Committee

Mr. Shyam Chainani proposed and it was

agreed to that while circulating the names of the candidates to be elected to the Executive Committee, the names of the President and Vice-Presidents need not be circulated as they were not concerned in the election process. It was also agreed that biodata of persons who may be co-opted to fill vacancies occurring during the term of office of a Committee should be published for the information of the members.

Agenda item 3: Other business

The Resolutions submitted by members were taken up for consideration.

1. "RESOLVED that Accounts of the Society be finalised within 3 months of closure of the books of accounts, and that the Annual General Meeting of the members be held within one month of the same." *Proposed by*: Sunil Zaveri and *Seconded by*: Parvish Pandya.

was considered and after discussion was accepted in the revised form given below:

> "RESOLVED that the Accounts of the Society be finalised and submitted for auditing by the end of June".

2. "RESOLVED that the Nett Sales Proceeds realised by the Sale of Greeting Cards and Calendars be credited to the Members' Activities Corpus Fund." *Proposed by*: Parvish Pandya; *Seconded by*: Nosherwan Sethna.

This was considered along with a similar Resolution proposed by Ms. Heta Pandit, and seconded by Debi Goenka reading:

> "RESOLVED that the nett sale proceeds realised by the sale of Greeting Cards and Calendars be credited to a 'Members' Activities Corpus Fund", the interest from which shall be used solely to finance Members' Activities."

Both these Resolutions were withdrawn when Mrs. D. S. Variava explained to the members the purpose for which these funds were set aside.

During the discussion it was suggested by Ms. Heta Pandit that New Activities (reference to Greeting Cards) if undertaken by the Society should be reported in the *Hornbill.*

3. "RESOLVED that the Balance amount of Rs. 89,340.39 in the Centenary Fund be transferred to the Library Corpus Fund." *Proposed by*: Nosherwan Sethna and *Seconded by*: Sunil Zaveri.

This was considered along with a similar Resolution proposed by Mr. Debi Goenka and seconded by Ms. Heta Pandit.

> "RESOLVED that the balance amount in the Centenary Celebrations Fund be transferred to the Library Fund."

were withdrawn following the explanation that these funds would be used for the publication of the Centenary Seminar Proceedings.

The Resolution put forward by Ulhas Rane, reading

> "RESOLVED that the following correction to be made in Agenda Item No. 2:
>
> > "Election of the Executive Committee for 1986-87 as provided under Rule 32.
> >
> > "The list of names of persons nominated should be also for the term 1986-87.
> >
> > "It is further RESOLVED that the General Body confirms and approves that the outgoing committee elected for 1983-84 had also worked for the year 1985."

was put to vote and accepted.

The following resolutions put forward by Mr. Debi Goenka, Ms. Heta Pandit and N. D. Mulla.

> "RESOLVED that the sum of over Rs. 27,000/- that was stolen at Bharatpur because of the negligence on the part of the Project Authorities and which is now irrecoverable because of flagrant viola-

tions of Rule 63 on the part of the Executive Committee, should be reimbursed to the Society by the members of the Executive Committee of 1983-84."

Proposed by: Debi Goenka and *Seconded by*: Ms. Heta Pandit was withdrawn on the condition that Rule 63 would be deleted during the revision of rules and the members advised at the next Annual General Meeting.

2. "RESOLVED that a Board of Editors be appointed by the Executive Committee for the Journal comprising of at least two experts in each of the following fields: mammals, birds, reptiles, invertebrates, insects, plants, fishes and wildlife." *Proposed by*: Ms. Heta Pandit and *Seconded by*: Mr. N. D. Mulla.

The Curator explained the mode of operation of the *Journal* and advised that all papers were reviewed by referees who were experts in their fields and only accepted for publication if approved by the referees. In some instances referees advised revision. This procedure has been found quite effective. The resolution was put to vote and was lost by 11 voting for and 14 against.

It was, however, agreed that the Executive Committee should reconsider the Editorial policy.

5. "RESOLVED that the draft minutes of the Annual and Extraordinary General Meetings be circulated within three weeks to all members of the Society present at the Meeting; the Minutes should be approved formally by the members present, at the next Annual Meeting", *Proposed by*: N. D. Mulla and *Seconded by*: Ms. Heta Pandit.

was finalised in two parts at Mrs. D. S. Variava's instance. The first part was amended to read:

> "RESOLVED that the draft Minutes of the Annual and Extraordinary General Meetings be circulated within six weeks to all members of the Society present at the meeting."
>
> "RESOLVED that the draft of the minutes be confirmed at the next Annual General Meeting".

Put to vote the amended Resolutions were passed with 20 members voting for with one voting against.

A Resolution of appreciation moved by Mrs. D. S. Variava and seconded by Mr. D. J. Panday at the rediscovery of Jerdon's Courser was unanimously accepted.

The meeting terminated with a vote of thanks to the Chair.

MINUTES OF THE EXTRAORDINARY GENERAL MEETING OF THE SOCIETY HELD FOR DISCUSSING THE PROPOSED CHANGES IN THE RULES

An Extraordinary General Meeting of the Bombay Natural History Society was held on Thursday, the 19th December 1985, at Hornbill House at 6 p.m. when the following were present:

1. Mr. Humayun Abdulali
2. Mr. Nitin Jamdar
3. Ms. Heta Pandit
4. Mr. N. P. Behramfram
5. Mr. Debi Goenka
6. Dr. (Mrs.) S. Unnithan
7. Dr. Robert B. Grubh
8. Mr. Parvish Pandya
9. Dr. A.N.D. Nanavati
10. Mr. Dilip Patil
11. Mr. D. J. Panday
12. Mr. M. D. Agharkar
13. Dr. C. V. Kulkarni (in the chair)
14. Mr. D. C. Balsara
15. Mr. S. A. Hussain
16. Ms. Uma Roy Choudhury
17. Mr. S. N. Mistry
18. Mr. Sunil R. Zaveri
19. Mrs. D. S. Variava
20. Mr. Bansi Mehta
21. Mr. Cyrus J. Guzder
22. Mr. N. D. Mulla
23. Mr. D. P. Bannerji
24. Mr. Sorab D. N. Gandhi
25. Cdr. GVK Unnithan
26. Dr. A. K. Joshee
27. Mr. Suresh Bhatkal
28. Mr. G. L. Kalro
29. Mr. A. V. Ghangurde
30. Mr. Ulhas Rane
31. Ms. Sumati Sampanene

Mr. D. J. Panday proposed Dr. C. V. Kulkarni to the Chair and was seconded by the Honorary Secretary.

Dr. C. V. Kulkarni explained to the audience the purpose for which they had assembled, namely to discuss the proposed amendments to the Rules and Regulations of the Society. He pointed out that the amendments were based on the suggestions received by the Executive Committee from members and have been circulated to all members. He further stated that Mr. M. D. Agharkar headed the sub-committee which worked on the suggestions made by the members, and drafted the present amendments which were to be discussed.

Dr. Kulkarni also explained to the meeting that the suggestions made by Mr. Ulhas Rane were inadvertantly omitted to be included in the papers submitted to Mr. M. D. Agharkar, and as such had to be considered at the current meeting.

Mr. Agharkar then explained that a sub-committee went through the amendments and he examined all the suggestions made by different members and then drafted the present amendments after discussing them with the Executive Committee.

The draft of the rules to be amended were sent to 2350 members of the Society (excluding student members, and members overseas), and the approval or otherwise received from 75 individuals is summarized in the paper put before the members.

A discussion followed. Mr. Humayun Abdulali pointed out the inadvisability of the members present for the current Extraordinary

General Meeting to approve or otherwise the views of 75 members who responded to the circular; and the most that could be done was to discuss the rules to be amended one by one without any resolutions being passed thereon.

The Chairman pointed out that this meeting was called for discussion of all the amendments and to ascertain the views of members thereon, and it was not proposed to pass any resolutions at the meeting.

Mr. Abdulali also told the audience that his several queries as to whether the amendments of rules would be done by referendum or otherwise, had failed to elicit a response from the Society's Executive Committee for reasons unknown. Mr. Abdulali was supported by Messrs Debi Goenka, N. D. Mulla, Ulhas Rane, Sunil Zaveri, and Bansi Mehta. Mr. Nitin Jamdar pointed out that the Society had stated in the monthly programme sheet circulated among members that the Special General Body Meeting called for on 19th December 1985 was "for the amendments of BNHS rules". It was explained that the programme notice was not an official notice of the meet and the error was regretted. Mr. S. A. Hussain informed the audience that many of the overseas members he met wanted to know the reason why they are not able to vote in the meetings of the Society of which they are members. It was explained that this was due to logistic factors which would usually prevent our receipt of the replies in time. Mr. Hussain then suggested that air mail communications should be sent to those members willing to pay the air mail charges, and it was agreed that this would be considered.

The meeting then proceeded with the discussion on the rules one by one and the suggestion made were recorded by Mr. M. D. Agharkar for consideration and final adoption.

The Honorary Secretary asked whether members had objections to a referendum when it was obviously in the interest of the Society to get a response from all rather than from a small number able to attend the meeting. Several members opined that a referendum may be acceptable provided that all amendments proposed, and not merely those approved by the Committee, were voted on in such a referendum. This was agreed to.

After going through all the rules listed in the circular the meeting terminated with a vote of thanks to the Chair.

THE SOCIETY'S PUBLICATIONS

The Book of Indian Animals, by S. H. Prater, 4th edition (reprint). 28 plates in colour by Paul Barruel and many other monochrome illustrations. Rs. 85.00
(*Price to members Rs.* 65)

The Ecology of the Lesser Bandicoot Rat in Calcutta, by James Juan Spillett. Rs. 10

The Book of Indian Birds, by Sálim Ali. 11th (revised) edition. 74 coloured and many monochrome plates. Rs. 75.00
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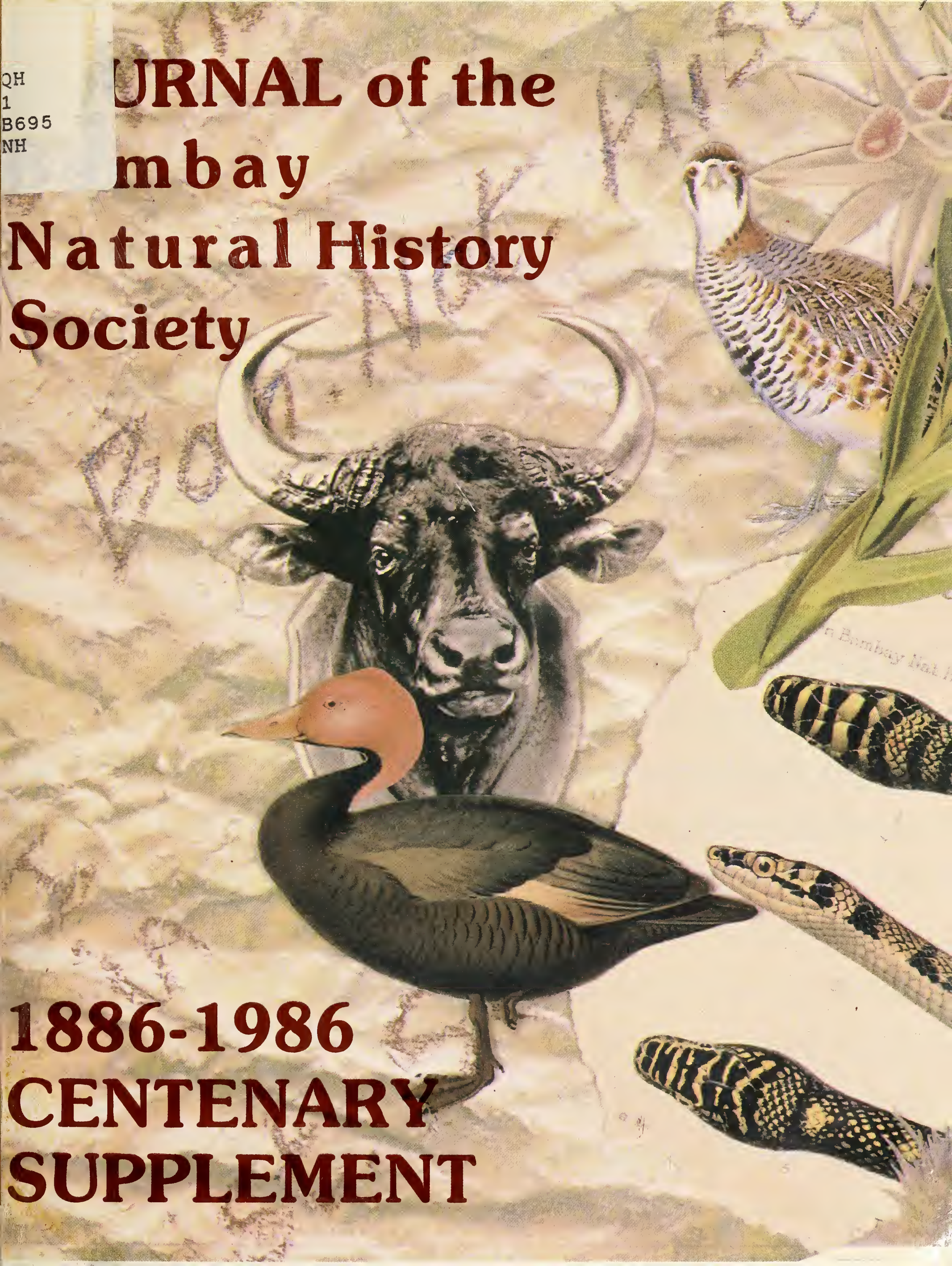
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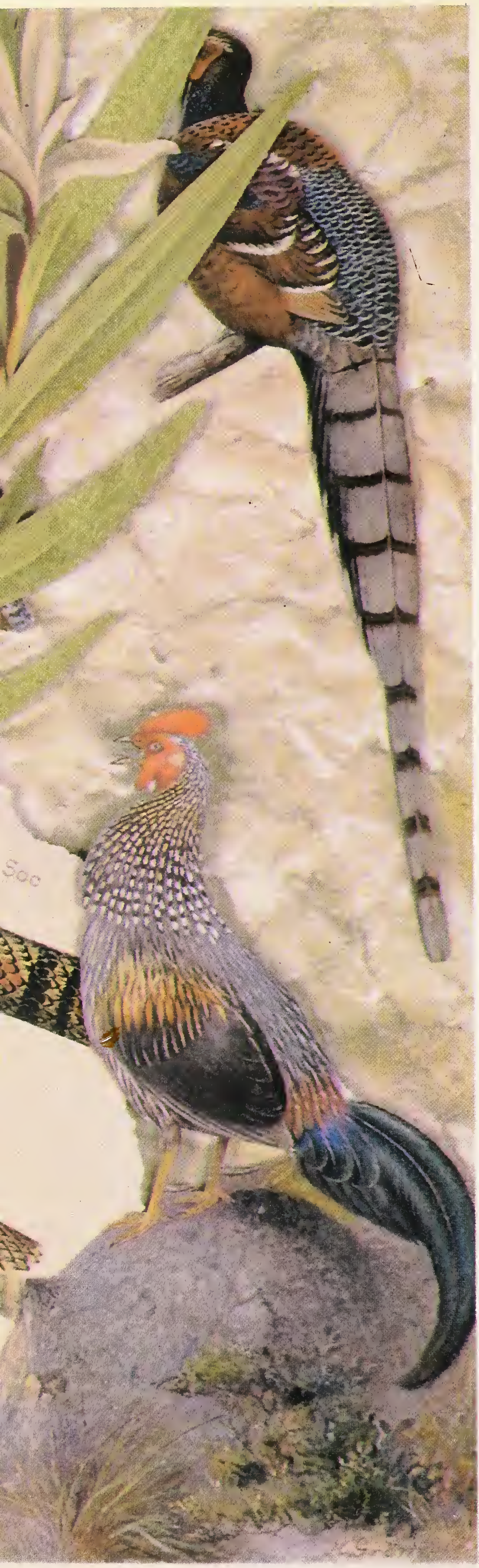
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THE JOURNAL: ITS ROLE IN INDIAN NATURAL HISTORY

SALIM ALI

By 1886 — three years after the founding of the Bombay Natural History Society — the largely attended monthly meetings of its fast growing membership had become very popular but were tending to become more like social get-togethers than scientific seminars. To give the Society's serious activities meaningful significance it was considered desirable to publish a quarterly journal for maintaining a permanent record of the business transacted at the meetings — of the papers read and discussed and of the natural history specimens collected, exhibited and described by members, and hunting experiences of discerning sportsmen. Such a publication, it was felt, would also help to stimulate an intelligent and well-informed interest in Nature among the many who, though naturalists in the truest sense of the term, lacked a formal biological background. It would, moreover, keep the scattered outstation members in touch with the Society and with each other and encourage their participation in its activities. Up to that time there was no publication devoted to natural history in Bombay Presidency nor indeed in the Subcontinent as a whole. Little was known and recorded, and vast tracts of the country lay unexplored for their animals and plants. Additional reading matter for the journal would be contributed by members with specialized interests such as mammals, birds, insects etc. and by perceptive sportsmen-naturalists recording their observations on the animals they hunted — their habits, food, behaviour, reproduction and other facets of their ecology. To gather representative material for building up the reference collections and for the journal, five sections were formed each of members specially qualified in the different branches of natural history: Mammals, Birds, Reptiles and Fishes, Insects and other invertebrates, and Botany. The secretaries of the respective sections would invite members to communicate their observations and also impel them to collect biological specimens for the Society's fast developing museum. How richly the decision to publish a journal paid off is evident from the popularity and scientific prestige it has developed for itself and the Society over the years.

The consistent and growing demand for complete sets of the Journal by the burjeoning educational institutions and libraries of colleges and universities within the country and scientific institutions abroad is a tacit recognition of the prestige and importance the Journal enjoys as a repository of Indian biology. Indeed for students of biology and wildlife conservation, and for a proper understanding of the ecology and bionomics of the subcontinent's prolific animal and plant life, the Journal has become indispensable. Since the cost of reprinting the earlier volumes — either out of print or brittled by age — would be uneconomical under prevailing financial constraints, and in order to meet the growing demand for complete sets as far as possible, it was decided to have the volumes reproduced in microfiche which would be economical in cost as well as in storage space which latter has become a serious problem for modestly endowed institutions. Microfiche films of Vols. 1-64 are now available and stocks of the printed subsequent volumes are as yet sufficient to meet a reasonable demand.

The first issue of the Journal Vol. 1(1), saw the light in January 1886 under the capable editorship of E. H. Aitken (EHA) who was the Honorary Secretary of the Bombay Natural History Society at the time. Another energetic naturalist-member, R. A. Sterndale, took over the editorship soon afterwards upon EHA leaving for England on home leave. Part 1 of Vol. 1 consisted of a total of 30 pages in all. It contains an Introduction and a list of the 236 members that stood on the rolls of the Society at the time, only 15 of whom, be it noted, were Indian. These pages are followed by a Catalogue of the Mammal and Bird specimens in the Society's collection and a pathetically skimpy list of books in its library — 27 titles in all, comprising Mammals, Birds, Reptiles, Fishes, Insects and other Invertebrates. Among them are 8 titles on Botany and 12 on general natural history, the last including 7 volumes of the rare *Calcutta Journal of Natural History*[1] and file Vols. I-VI of the *Asian* newspaper, both containing a wealth of invaluable archival references pertaining to shikar and wildlife in India of over a hundred years ago. Of literary contributions the very first is a "Note on an undescribed Hamalopsida" by Rev. F. Dreckmann. This is followed by a "Note on a probable new species of Ibex" by R. A. Sterndale and "A Note on the spider *Mygale fasciata*" by Capt. T. R. M. Macpherson. The issue closes with a note by EHA himself "On the mimicry shown by *Phyllornis jerdoni*" in the felicitous pithy style that characterizes all of this gifted naturalist's writings.

In the early days of the Journal, and until fairly recently — more or less all through the British period — the emphasis was largely on game animals and shikar. But the recorded experiences and field observations of well-informed and discerning sportsmen have helped substantially to build up our knowledge of the life histories not only of quarry species but also others of lesser interest to the sportsman. A large proportion of the natural history of our game animals, both mammal and bird, has been acquired in this way, especially since the Journal made its appearance. Most of such knowledge is seminal and would have remained unavailable but for the published notes and articles of observant sportsmen. The latter consisted chiefly of British district officials, Army personnel and planters dispersed in remote backwoods lacking social amenities and congenial company, who had therefore taken to natural history and shikar by way of relaxation and recreation, a few of them developing into reputable authorities in their special subjects. One of the most prolific of such sportsmen-naturalists was E. C. Stuart Baker whose long and popular serial on "Indian Ducks and their Allies", illustrated with beautiful coloured plates of waterfowl by some of the finest European bird artists of the day, started in 1897 and continued almost without any interruption for the next 10 years or more. The articles were highly appreciated by sportsmen all over the country and added substantially to the popularity of the Journal and to the strength of the Society's membership.

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[1] The first journal of its kind to be established in India. Published quarterly between 1840 (or '41) and February 1848.

The second number of Vol. 1, containing a heterogeneous variety of articles and notes on plants and animals — taxonomical, ecological and anecdotal — set the pattern which the rest of the volumes up to the present have more or less followed. The Miscellaneous Notes section which follows the main articles has always been the most popular feature with readers whose scientific interest is marginal; but many an anecdote casually recounted for its novelty for the writer has often proved of sufficient significance to be meaningful to a scientist as corroborative or supplementary evidence for some pet theory of his own.

From chiefly shikar in the early days of the Society the accent in the Journal has steadily shifted to conservation on the growing realization that all was not well with our wildlife and that the once teeming game was vanishing fast throughout the country. This was partly due to excessive hunting by unethical sportsmen and organized poaching for commercial gain by local shikaris, but mainly to the destruction of wildlife habitats by the thoughtless clearing of forest in later days and to large scale illicit encroachment of forest land by squatters and refugees or repatriates, often with the connivance of crooked politicians. Latterly the modern craze for monoculture, mostly of exotic fast-growing tree species to pander to the needs of industry, has also been responsible for the destruction of natural mixed forests which supported most of our wildlife.

Throughout its existence the Society has been deeply concerned about wildlife and environmental conservation, and the Journal has functioned as its main "mouthpiece" and an effective vehicle for its campaign against public and official apathy. All these destructive forces had to be resisted and countered by creating a healthy public opinion and pressurizing and persuading government to institute adequate legislative measures.

The special volume published in 1933 to commemorate the Jubilee year of the Society gives an excellent account of the Journal and its editors and functioning up to the 36th volume. These volumes represented the Society's contribution to the advance of our knowledge of the botany, zoology and nature conservation of the Subcontinent and adjoining countries. They point out how, apart from the results of scientific researches and field surveys, the Journal is unique in that it contains a vast amount of data — the notes and observations contributed by perceptive field naturalists which have helped significantly in promoting the refreshing trend of Indian biology from the museum to the field — from the study of the dead to the living : from taxonomy to ecology.

The need for protecting wildlife against unregulated hunting and large scale commercial poaching by village shikaris was increasingly felt by forest officials and discerning sportsmen even since the early years of the 20th century. Sporadic efforts had been made by far-sighted individuals to arouse the concern of the discerning public and the authorities to the deteriorating status of forests and wildlife — game animals in particular — and some local legislation was also enacted by Provincial governments for their own forests. But the absence of an influential non-governmental central forum for disseminating a consensus of the views of enlightened and knowledgeable naturalists and sportsmen on conservation problems on a countrywide scale stood in the way of introducing any comprehensive legislation applicable to British India as a whole. The Bombay Natural History Society, founded in 1883 by a group of perceptive naturalists, provided just such a forum. Its membership constituted the nucleus of the sporting fraternity in India at the time, the majority of whom were British officials and professional men zealously interested in the preservation of game animals even though maybe sometimes not from purely altruistic motives!

The wildlife protection movement visibly began in 1869 and culminated in The Wild Birds and Game Protection Act of 1887 (Act XX of 1887), shortly after the Journal was launched. Most of the individuals responsible for ushering in this legislation had joined the Society by then, helping thus to present a consolidated demand. Although this Act was intended to cover all animals in the whole of British India, it was in fact directed chiefly against the destruction of Birds, and was at first restricted only to Local Governments (Municipalities, Cantonments) who were empowered to apply its provisions to any other game within their limited jurisdictions. It was in this context that the Journal fired the first shot in its conservation campaign, as early as 1888 (Vol. 3) when, in response to a reference made to it by the British President of Ahmedabad Municipality the Society's Committee recommended that *all* wild animals in the neighbourhood of Ahmedabad, including game birds as well as all others, should be protected by law between 15 July and 15 October — the general breeding season. Criticisms and dissatisfaction as to the inadequacy of the Act resulted in a new all-India Act 25 years later "to make better provision for the protection and preservation of certain species of wildlife" called The Wild Birds and Animals Protection Act, 1912, which received the assent of the Governor-General on 18 September 1912 and remained in force till superceded by a newer and more comprehensive legislation.

This was a distinct step forward in the recognition by the Central Government of the importance of wildlife to the country. It was the Journal that published some useful criticisms and suggestions for emendations in the Act for considerably simplifying the implementation of various provisions and rendering it more practical and effective. Some of these suggestions were accepted by Government, especially as to the inclusion of correct vernacular names of animals listed in the Schedule for non English-knowing persons. The Act of 1912 was a marked advance on its 1887 predecessor which it replaced. But in the year from immediately after World War I great disorganization was caused through many of the conservation-minded British forest officers having left the country on war service and the general slackening in the law and order situation. Through all these vicissitudes the Journal kept plugging away in its campaign to create an awareness among the public of wildlife and the growing need for nature conservation. But it was not till the Golden Jubilee of the Society in 1933 that wildlife preservation really came into sharp focus. It was the masterly address delivered by Mr. S. H. Prater, the Society's Curator, on that occasion on "The Problems of Wildlife Protection in India" that seriously set the ball rolling and paved the way for the calling by the Viceroy (Lord Willingdon) — the Patron of the Society — of the all-India meeting at Delhi of prominent naturalists and sportsmen to review the deteriorating situation and suggest practical methods for effective conservation of wildlife. Though a follow-up was much delayed owing to the interruption caused by World War II (1939-46), the formation of the Indian Board for Wildlife in 1951 — as soon as conditions became more or less stabilized after Independence and Partition — was a direct result of the Delhi meeting. The disorganization of the services during the war and its political aftermath had aggravated the wildlife situation alarmingly and in certain areas, erstwhile famous for game and shikar such as many of the princely states, wildlife, particularly 'prime' species like the tiger, had been completely wiped out. It was chiefly during this depressing period that the Journal proved the most effective champion for the cause. And it was the untiring and dedicated advocacy of the Society's stalwarts like Col. R. W. Burton, E. P. Gee and R. C. Morris, who through their authentic well-researched articles in the Journal, kept the subject in sharp focus with government and the discerning public, leading to the establishment of most of the National Parks, Wildlife Sanctuaries and nature reserves that exist today, and to protective legislation culminating in the comprehensive Wildlife (Protection) Act of 1972. With proper implementation, this central legislation — itself based on the provincial Bombay Wild Birds and Wild Animals Preservation Act of 1951 (for which again BNHS was largely responsible) — should go a long way to saving what can still be saved of the splendid wealth and diversity of our once teeming wildlife and its natural habitats.

A succint account of the Journal and its editors and achievement in the way of popularizing Indian natural history and arousing an interest in nature in the 'common man' in the first 36 volumes published between 1886 and 1932 will be found in the special volume commemorating the 50th anniversary of the Society and does not need repeating here. It had become an unwritten convention for the Honorary Secretary of the time to be the editor; though in later days after appointment of the first stipendiary Curator (N. B. Kinnear) in 1907, most of the actual editing and donkey work connected with the publication of the Journal fell to the lot of the professional Curator. The Curator at the completion of Vol. 36 and for the next 15 years, till he retired in 1948 to settle down in the U.K., was Mr. S. H. Prater. Prater remained the *de facto* editor of the Journal, associated for varying periods from time to time with the Honorary Secretary of the day. Followed an 'interregnum' while the search for a worthy successor to Prater was on, during which the Journal was edited by the 'reigning' Honorary Secretary assisted by one or two, or a small panel, of knowledgeable members: thus vols. 48-57 were edited by Salim Ali (who simultaneously also acted as Curator for a brief period), 58 & 59 by Humayun Abdulali & Rev. Fr. Santapau, 60 & 61 by Zafar Futehally & Santapau, 62 by H. Santapau, D. E. Reuben, Zafar Futehally & J. C. Daniel, the last named having meanwhile been appointed Curator of the Society. Thereafter Vols. 63-66 were edited by Santapau, Futehally & Daniel. After Vol. 66 and to date J. C. Daniel and the Honorary Secretary (Dr. A. N. D. Nanavati) and one or two specialist members took over the editorship.

It is no exaggeration to say that the Journal reached the peak of its reputation and credibility during the editorship of Prater especially while associated with Sir Reginald Spence as Honorary Secretary. Spence was an influential and dynamic personality and took a more active part in the affairs of the Society and in editing the Journal than most others. As executive editor Prater's name had become synonymous with the Bombay Natural History Society and he is largely responsible for the international recognition the Journal has acquired as the foremost natural history publication in Asia. Prater's flair for guzzling through heavy scientific literature and translating its essentials into simple jargon-free language for the layman was outstanding. He was, moreover, blessed with a phenomenal memory which enabled him to comment rationally on whatever he was editing or by immediately recalling what he had read on the subject, maybe years before, and could lay his hands on the source for reference without hesitation or fumbling.

Prater set the trend followed to this day in the editing and presentation of the best in natural history writing and research in the Indian Sub-continent.

A REVIEW OF INFANTICIDE AMONG HANUMAN LANGURS AND OTHER PRIMATES

Y. SUGIYAMA[1]

1. *First Discovery and Response to it*

The first discovery and the scientific description of the conspecific infanticide among larger mammals in their own habitat was recorded on the Hanuman langur (*Presbytis entellus*) at Dharwar (or Dharwad), Karnataka, south India (Sugiyama 1965). Before this study there might have been facultative observations by naturalists on conspecific killings among langurs or other animals and there was an intensive field study on the Hanuman langur (Jay 1962, 1965). However there was no record of conspecific killing which made clear the relation among killer, victim and the particular situation with special reference to the group structure and ecology of the species. The reason why the above study made the first discovery is found in its methodology. First, the individual identification of all animals of a group or even of a local population. Second, continuous observations on them through long term studies. They are common, at present, for sociobiological studies in free-ranging as well as in captive colonies.

The first report on the conspecific infanticide written in an European language was published in 1964 (Sugiyama 1964), however, there was little response. In late 1964 I presented a paper at an international symposium on primate communication at Montreal organized by Dr. S. A. Altmann. In this paper, I described the regular occurrence of conspecific infanticides in Hanuman langurs and discussed its relation to sexual drive of surplus (extra-troop) males, effect of incidents and the long-term continuation of one-male troop structure of this species at Dharwar (Sugiyama 1967). But the chairman of the session concluded that, "the periodic liquidation of the baby langurs impresses me as being potentially dysgenic in its consequences" (Warren 1967).

For about 10 years a similar responses continued, that is, the conspecific infanticide was thought to be very special, exceptional and abnormal behavior. Only the response of Japanese field primatologists was different from the first publication. They recognized the regularly occurring conspecific infanticide of langurs as a part of adaptive mechanism to maintain the one-male troop structure (Itani 1972).

At the 2nd All India Congress of Zoology held at Varanasi (or Benares), Uttar Pradesh, in 1962 Dr. M. D. Parthasarathy and I presented a paper of our field study on the langur social structure with special reference to repeated infanticides. Dr. M. L. Roonwal, Director of the Zoological Survey of India, showed much interest in our study and after he was promoted to the Vice Chancellor of the University of Jodhpur, Rajasthan, he began to work with his student, S. M. Mohnot, on the field study of langurs which live near Jodhpur. Therefore, the second scientific report on the infanticide of langurs came out in 1971 (Mohnot 1971). The basic social structure and the process of the infanticide were almost same as those found at Dharwar. That is, the bisexual troop consisted of a male and some females with their offspring, surplus males in an all-male group attacked the former, they ousted the troop male and his sons, only a dominant male from among the attackers took over the females, he bit and killed all infants and, then, mated with females including the victims' mothers.

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[1] Kyoto University Primate Research Institute, Inuyama 484, Japan.

Rudran (1973) reported from Ceylon (Sri Lanka) on the purple-faced langurs (*Presbytis senex*) and Hrdy (1974) from Abu, Rajasthan, on the Hanuman langur. Furthermore, on the lion (*Panthera leo*) of Serengetti, East Africa (Bertram 1975) and on a south American monkey, the red howler (*Alouatta seniculus*) (Crockett & Sekulic 1984) very similar infanticides by a new male after the usurpation of the troop (or dominant status) were repeatedly confirmed. Other than the repeated and regular occurrences of infanticides mainly by an invading male after the replacement of the resident male, mentioned above, facultative infanticide have been confirmed at least in 13 species of non-human primates (Itani 1982, others).

2. *From "Maladaptive" to "Adaptive"*

Accompanying the increasing observations of conspecific infanticides much interest came to be concentrated on the factors which lead animals to kill infants.

Curtin & Dolhinow (1978) stated that "langurs of Dharwar (and other infanticidal areas) concentrated in what little remained and greatly disturbed habitat by human activities". Boggess (1979) also believed that the "infant killing in association with troop social change represents maladaptive behaviors occurring in isolated and rare situations or in populations characterized by extreme crowding". Finally they concluded this behavior as "social pathology". These responses were the last flame of the old candle which tried to lock this abominable behavior of our relatives in a special box labelled dysgenic, abnormal, maladaptive and pathological behavior without recognition of details of incidents and environment.

Actually the forest of western Dharwar during the studies was well grown secondary forest for the climate of the given area with minor effect of human activities. The forest of about 400 km^2 was connected with adjacent forests through scrub forest and patchy cultivated field with gallery forest which are also favourable habitat for langurs.

From the time of the first discovery I have never stated that this behavior is either normal or abnormal, or, pathological or not. Because once a given behavior is labelled "abnormal" or "pathological", one tends to stop searching for more exact reasons why a male langur killed all infants of the troop he has usurped and why victim's mother soon mated with him. Nevertheless I (Sugiyama 1967) pointed out that, "because a female langur usually delivers an infant every 2 or 3 years, the loss of the infant has the effect of advancing the estrus of the female".

I also said that the local difference of occurrence and non-occurrence of troop usurpation and infanticide is related to the ecological characteristics of the habitat, population density, troop type (one-male or multi-male) and other sociological characters (Sugiyama 1976).

Hrdy (1979) classified the factors of conspecific infanticide among animals and carefully examined them. Then, she refined my preliminary hypothesis and concluded that the infanticidal male increases his fitness through elimination of his predecessor's infants and she raised the sexual selection hypothesis. She also paid attention to the local difference of the same species, that is, infanticide may occur in some areas but not in others and concluded that the most obvious factor influencing facultative expression of the infanticidal trait is population density.

In fact Vogel & Loch (1984) confirmed that the infanticidal male exactly gets his own offspring earlier than non-infanticidal male in a same situation if he eliminates a dependent infant from its lactating mother. Most successors reconfirmed the above reproductive advantage of the infanticidal male who kills infants after the troop usurpation and then, mates with the mothers of victims in most cases as seen at Dharwar when first reported. Therefore the hypothesis is now called the male reproductive strategy hypothesis.

Before Hrdy (1979) most of hypothesis which searched the factor of conspecific infanticide tried to find out the direct factor of the infanticide or motives of the behavior and possible factors. There were common motives in many cases and research areas, however, some motives were not seen in other non-human primate species.

All conspecific infanticides of langurs occurred after troop usurpation. Infants of the troop were killed by the usurper who had had no chance to mate with females before it. After infants were eliminated their mothers soon mated with the infanticider and, then, they gave birth to infants sired by him. Many other species of non-human primates in which infanticide occurs also showed similar process. They were mostly folivores, they had one-male troop structure and the population density was rather high. However, only the male reproductive strategy hypothesis does not have exception and this hypothesis could explain the ultimate factor how infanticidal males reproduced more offsprings than non-infanticidal ones in the same population and how this behavior evolved. After 1980 all studies on the infanticide emphasised effectiveness of this hypothesis. The book edited by Hausfater and Hrdy (1984) collated the results.

Today, however, some studies reject coexistence of any hypothesis focusing on proximate factors with the ultimate factor in emphasis of the male reproductive strategy or place proximate as well as ultimate factors in the same category and pick up only the male reproductive strategy as the correct factor (e.g., Sommer & Mohnot 1985). Here, I wish to comment only on one point. That is, proximate factors and ultimate factor(s) work at different levels of the biological mechanism and they must be examined separately.

3. *Necessity to search for Proximate Factors*

Boggess (1979) and Bishop (1979) emphasised that male langurs of Himalayan high altitude with low population density, Solu region, Nepal, neither take over the bisexual troop nor kill infants of the troop but freely emigrate from the natal troop and join other troops. Most of bisexual troops are multi-male type. Population density of langurs at the Kanha forest, 46.2/km², is lower than that of Dharwar, 85.3/km² (Sugiyama 1964), and higher than that of Simla of Himalayan high altitude. 24.6/km² (Sugiyama 1976). Recently at Kanha infanticides by invading males were confirmed to occur in a low frequency after troop usurpation (Newton 1985).

It is not possible to explain the total figure of infanticide of langurs and other animals only by the male reproductive strategy hypothesis. In other words, if we consider the reason of the local difference of the infanticidal frequency or the reason why it does not occur in some populations, we have to find out the proximate factors which depend on difference of environmental and social conditions; such as the topography and vegetation of habitat, food distribution, population density, troop type (one-male or multi-male) and male tenure length in a one-male troop.

Furthermore, when we consider the origin of this behavior there must be proximate factors or direct motive for invading males which led them to attack and kill infants of resident females of his usurped troop. Repeated occurence of infanticide might have led all or most invading males of a given population to kill infants as their evolutionary stable strategy pressing down the number of offsprings of non-infanticidal males. Even if the first infanticidal male had the benefit in his reproductive success he must have his own direct motive or reason to perform this violent attack on infants. The second and third infanticidal males must have too. In some populations of langurs where there is few or no infanticide most surplus males may gain cycling females and succeed to reproduce without killing infants. This must be the important cause for local and individual difference for infanticide among non-human primates.

Hrdy (1979) herself recognized the ultimate factor as well as the factor which influences the local differences, however, some of her successors in 1980's reject each of the proximate factors presenting an episode which is not related with a particular example of the suggested proximate factors.

Today, it is not possible to reject "social pathology hypothesis" without presenting and examining the exact definition and details of "pathology" and this kind of argument does not contribute to the solution of the problem. If one could suggest in late 1960's or early 1970's that the repeated infanticide of non-human primates after male replacement is the vivid and effective strategy for them specifically related with their social structure his article would have been ten times more valuable than recent such articles.

Conclusion

For establishing a certain behavior pattern, e.g., infanticide, as an evolutionally stable one may give benefits measured by reproductive success to the performer. However, in the process of evolution proximate factor or direct motive leads animals to repeat it. Basically depending on differences of environment and life form of each species existence or non-existence of the proximate factor strongly works in some populations and does not work much in other populations. Then, the local difference develops. Therefore the ultimate factor which may be common throughout a certain taxonomic group and the proximate factors which may be different to populations according to environment must be considered separately.

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A NOTE ON *RHINOLOPHUS PEARSONII* HORSFIELD, 1851 AND *RHINOLOPHUS YUNANENSIS* DOBSON, 1872 (CHIROPTERA: RHINOLOPHIDAE)

J. E. Hill[1]

The Asian horseshoe bats *Rhinolophus pearsonii* Horsfield, 1851 and *R. yunanensis* Dobson, 1872 are reviewed, defined and discussed, with confirmation of their status as distinct species.

INTRODUCTION

Classifications of the Asian bats of the genus *Rhinolophus* often reflect the pioneer work of Dobson in the decade 1871-1880 and its subsequent refinement by Andersen some thirty years later. Thus *R. yunanensis* Dobson, 1872 was put into synonymy by its author (1876, 1878) shortly after its description, a view confirmed by Andersen (1905). Since then it has been rarely used and following these authors was synonymized for many years with *R. pearsonii* Horsfield, 1851. However, Hinton & Lindsay (1927) employed it for a specimen from Meghalaya (Assam), and more recently specimens from Thailand led Hill (1975) to revive it again, but without detailed explanation, and to suggest in Lekagul & McNeely (1977) that it should be considered a distinct species. Modern compilers (Corbet & Hill 1982, 1986; Honacki *et al.* 1982) have adopted this opinion.

SYSTEMATIC SECTION

Rhinolophus pearsonii Horsfield, 1851

Rhinolophus pearsonii Horsfield, 1851: 33. Darjeeling, West Bengal, NE India.

Rhinolophus larvatus Milne-Edwards, 1872: 248, pl. 37a, fig. 1, pl. 37c, fig. 1. Moupin, Sichuan (Szechuan), S China. Not of Horsfield, 1823.

(?) *Rhinolophus pearsoni chinensis* Andersen, 1905: 289. Kuatun, Fujian (Fukien), SE China.

DESCRIPTION. Size medium to large (length of forearm 48-57 mm) for the genus; anterior noseleaf or horseshoe very large, completely covering the muzzle, anteriorly deeply emarginated and with a moderate covering of short hairs; internarial region slightly expanded, a little wider than the base of the sella, slightly cup-shaped; sella contiguous with internarial expansion, its basal third widened, upper two thirds a little constricted to form a parallel-sided structure with rounded apex; connecting process originating from rear of sella at or near its apex, in profile rounded, low, its height little more than that of the apex of the sella; posterior leaf triangular, cellular, high, its lateral margins very slightly concave, with pointed tip. The connecting process does not invariably arise from below the apex of the sella as is implied by Allen (1938) or by Sinha (1973). More often than not the point of origin on the sella is at or very near the summit of this structure: the assumption may arise from Andersen (1905) who in allying *pearsonii* to the *Rhinolophus macrotis* group gave as an essential external character for the group "rounded connecting process, starting from a point below the summit of the sella".

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Ears large, more or less triangular, bluntly pointed, the anterior margin of the ear convex, the posterior margin slightly concave just below the tip, then convex, with a deep, narrow emargination separating a large, rounded antitragal lobe; wing inserted at the ankle; third metacarpal the shortest, fourth metacarpal very slightly shorter than fifth; first phalanx of third digit not shortened, the second phalanx less than one and one half times its length; tibia long; foot small; calcar extending along about one third of the uropatagial margin.

Skull with short, wide braincase; strong sagittal crest bifurcating anteriorly to enclose a moderate frontal depression; rostral expansions well developed, inflated, wider than deep; zygomata strong, massive, zygomatic expansion greater than mastoid width; length of palatal bridge one third or a little less than one third the length of the maxillary toothrow; palate rounded, mesopterygoid fossa not widened; basioccipital narrow. Upper incisors ($i^{2\text{-}2}$) bicuspid, inwardly directed; anterior upper premolar (pm^2) large, with small cusp, usually in toothrow, sometimes very slightly extruded; second lower premolar (pm_3) small, almost entirely extruded from row or extruded with the anterior (pm_2) and posterior (pm_4) premolars in contact.

Measurements appear in Table 1. Those provided by Sinha (1973) for *R. pearsonii* as it is represented in the collections of the

TABLE 1

MEASUREMENTS (NUMBER OF SPECIMENS, MINIMUM, MAXIMUM, IN MM) OF *Rhinolophus pearsonii*

	India, Meghalaya, Sikkim, Nepal	Burma, China, N Vietnam	Thailand	BM(NH) 98.11.1.2 Holotype *chinensis* Fujian
Length of forearm	(11) 50.7–54.0	(3) 51.8–56.9	(3) 48.0–50.1	51.8
Length of tibia	(11) 26.0–27.4	(3) 26.2–26.7	(3) 25.6–27.1	26.7
Greatest length of skull to canine	(13) 22.6–23.8	(3) 22.2–23.5	(2) 21.8, 22.1	23.5
Condylocanine length	(12) 20.1–21.2	(3) 20.1–21.0	(2) 19.7, 19.9	21.0
Width of rostrum	(17) 5.8– 6.2	(4) 5.5– 6.1	(3) 5.8– 6.0	6.1
Width across anteorbital foramina	(17) 5.1– 5.9	(3) 5.4– 5.9	(3) 5.5– 5.6	5.8
Least postorbital width	(17) 2.2– 2.7	(3) 2.2– 2.6	(2) 2.4, 2.4	2.5
Zygomatic width	(14) 11.5–12.1	(3) 11.5–12.0	(3) 11.0–11.4	12.0
Width of braincase	(15) 9.4– 9.8	(3) 9.3– 9.9	(2) 9.4, 9.8	9.9
Mastoid width	(13) 10.4–10.9	(3) 10.5–10.9	(2) 10.3, 10.6	10.9
c^1-c^1 (alveoli)	(16) 5.7– 6.4	(4) 5.7– 6.3	(2) 5.7, 5.8	6.3
m^3-m^3 (alveoli)	(16) 8.3– 9.0	(4) 8.1– 8.8	(3) 7.8– 8.0	8.8
c-m^3	(17) 9.1–10.0	(4) 8.9– 9.6	(2) 8.3, 8.6	9.3
Length complete mandible from condyles	(12) 15.4–16.5	(2) 15.5, 15.8	(1) 14.6	15.8
Length right ramus from condyle	(17) 16.1–17.0	(4) 16.0–16.5	(3) 15.0–15.5	16.5
c-m_3	(16) 9.5–10.6	(3) 9.4–10.0	(3) 8.7– 9.1	10.0

Zoological Survey of India apparently refer in part to a composite series that includes a specimen of *R. yunanensis.* The list of material examined by Sinha includes a male example in alcohol from Hotha, Yunnan, SW China, collected in 1868 (misprinted 1863): this is apparently one of the original specimens of *yunanensis* (see below). Thus at least the values for external measurements (length of forearm, length of tibia) given by Sinha (loc. cit.) for *R. pearsonii* have as their maxima dimensions that most probably correctly refer to *R. yunanensis.*

DISTRIBUTION. INDIA: N Uttar Pradesh (Wroughton, 1914); N West Bengal (Horsfield, 1851; Wroughton, 1916); Sikkim (specimen in British Museum (Natural History)); Meghalaya (Assam) (Hinton & Lindsay, 1927); NEPAL (Hinton, 1923); BHUTAN (Saha, 1980); BURMA (Andersen, 1907); THAILAND (Hill, 1975; Lekagul & McNeely, 1977); CHINA: S Xizang Zizhioqu (Tibet) (Cai & Zhang, 1981); Yunnan (Thomas, 1923); Sichuan (Szechuan) (Milne-Edwards, 1872); Guangxi (Kwangsi) (Shih, 1930a); Hunan (Shih, 1930b); Guangdong (Kwantung) (Shih, 1930c); Fujian (Fukien) (Thomas, 1898); Guangzhou (Canton) (Mell, 1922); Anhui (Anwhei) (Honacki *et al.*, 1982); VIETNAM: Tonkin (Osgood, 1932); MALAYA (Honacki *et al.*, loc. cit.)

The species is known to occur at relatively high altitudes, having been obtained at 6000 ft at Lwarkhet, north of Almora, Uttar Pradesh, N India (Wroughton, 1914), at 10000 ft in the Li-Kiang Range, Yunnan, China (Thomas, 1923) and at 11000 ft at Parchung, about 40-50 miles N of Katmandu, Nepal (Hinton, 1923).

SUBSPECIES. The subspecies *R. pearsonii chinensis* Andersen, 1905 was based originally on a single specimen (BM(NH)) 98.11.1.2 from Fujian (Fukien), SE China which according to its describer could be distinguished from the nominate subspecies (specimens from Darjeeling and Masuri, West Bengal, NE India) by its shorter tibiae, slightly smaller skull, narrower maxillary width and shorter mandible and toothrows. Subsequently Andersen (1907) reported *chinensis* from Taho, in the Karen Hills, northeast of Tounghoo, S Burma, and more recently Shih (1930b, c) recorded it from Hunan and Guangdong (Kwantung), China, while Osgood (1932) reported specimens from various localities in Tonkin, Vietnam. The limited sample of specimens from China, Burma and Vietnam (including the holotype of *chinensis* and the specimen from Taho) in the collections of the British Museum (Natural History) does not support this division, current measurements with a dial reading micrometer failing to agree in every instance with those recorded by Andersen (1905, 1907) for the Chinese and Burmese specimens. The holotype of *chinensis* is similar in size in most respects to specimens from Darjeeling and Masuri and moreover many of its dimensions exceed those of specimens obtained in Nepal and Meghalaya since Andersen wrote. However, a similarly restricted sample of specimens from Thailand is a little smaller on the whole than those from the remainder of the range as represented in the collections in London. In these circumstances the continued maintenance of *chinensis* as a valid subspecies seems doubtful.

REMARKS. Dobson (1876, 1878) placed *R. larvatus* Milne-Edwards, 1872 in the synonymy of *R. pearsonii* (see below) where it has since remained, this opinion being supported by Andersen (1905). The original description and illustrations of *larvatus* indicate that particularly with regard to size of skull it is indeed synonymous with *pearsonii.* Anderson (1881) reported *R. mitratus* Blyth, 1844 from Darjeeling, West Bengal, on the basis of a specimen (105c) in the Indian Museum, Calcutta (the collection of the Zoological Survey of India). According to Sinha (1973) this specimen is however an example of *R. pearsonii*, subsequently recorded from the Darjeeling District by Wroughton (1916).

Rhinolophus yunanensis Dobson, 1872

Rhinolophus yunanensis Dobson, 1872: 336. Hotha, Yunnan, S China.

DIAGNOSIS AND DESCRIPTION. Externally exactly like *R. pearsonii* but larger: similarly, the skull precisely resembles that of *pearsonii* in its structural features but is larger and more massive, with correspondingly heavier teeth. Measurements appear in Table 2.

DISTRIBUTION. INDIA: Meghalaya (Dobson, 1874, Hinton & Lindsay, 1927); N BURMA (specimens in British Museum (Natural History); THAILAND (Hill, 1975; Lekagul & McNeely, 1977); CHINA: Yunnan (Dobson, 1872).

In Meghalaya Dobson (loc. cit.) records the species from Tupai Mukh in the Lushai Hills while Hinton & Lindsay (loc. cit.) report it from Dening, in the Mishmi Hills, at 2250 ft, these latter authors also recording *R. pearsonii* from the Jaintia and Khasi Hills. Burmese specimens of *yunanensis* are from the Nam Tamai Valley (27° 42′ N, 97° 50′ E), Kajihtu

TABLE 2

MEASUREMENTS (NUMBER OF SPECIMENS, MINIMUM, MAXIMUM, IN MM) OF *Rhinolophus yunanensis*

	BM(NH) 21.12.5.2 Meghalaya	Burma	Thailand	BM(NH) 9.4.4.3 Syntype *yunanensis* Yunnan
Length of forearm	59.4	(4) 55.0–57.3	(7) 55.5–59.6	57.3
Length of tibia	30.3	(4) 28.6–30.9	(9) 28.3–31.8	28.4
Greatest length of skull to canine	25.4	(3) 24.5–25.0	(8) 25.1–26.9	26.0
Condylocanine length	22.8	(3) 22.4–23.0	(6) 22.8–24.3	23.5
Width of rostrum	6.3	(4) 6.3– 6.7	(9) 6.4– 6.9	6.4
Width across anteorbital foramina	6.0	(4) 5.8– 6.4	(9) 6.3– 6.6	6.0
Least postorbital width	2.4	(3) 2.2– 2.5	(8) 2.4– 2.9	2.5
Zygomatic width	12.6	(3) 12.2–13.0	(8) 12.4–13.9	12.6
Width of braincase	10.1	(3) 9.9–10.5	(7) 10.6–11.2	10.5
Mastoid width	11.4	(3) 11.0–11.9	(7) 11.7–12.0	11.3
c^1-c^1 (alveoli)	6.8	(4) 6.7– 6.8	(8) 6.6– 7.1	6.6
m^3-m^3 (alveoli)	9.0	(4) 9.3– 9.7	(8) 9.3– 9.9	8.8
c-m^3	10.1	(4) 10.1–10.5	(8) 10.2–11.1	10.2
Length complete mandible from condyles	17.6	(3) 17.0–17.5	(7) 17.7–18.6	17.9
Length right ramus from condyle	18.2	(4) 17.7–18.2	(8) 18.2–19.3	18.6
c-m_3	10.9	(4) 10.8–11.1	(8) 11.0–11.9	10.8

(26° 18′ N, 97° 50′ E) and Mahtum (26° 06′ N, 97° 58′ E), Andersen (1907) having recorded *pearsonii* from the Karen Hills to the south. In Thailand *yunanensis* is reported from the provinces of Chiang Mai, Nan, Sara Buri and Rat Buri by Hill (loc. cit., who also reported *pearsonii* from Chiang Rai, Chiang Mai, Nan, Lop Buri, and Kanchanaburi) and from Chiang Dao by McFarlane & Blood (1986). The type locality, Hotha, in Yunnan, SE China is not far distant from the Li-Kiang Range whence Thomas (1923) reported *pearsonii.*

ORIGINAL SPECIMENS. According to Dobson (1876: 44, 1879) the original series of *R. yunanensis* consisted of two male specimens and one female example. However, although Dobson (1876: 194) and Anderson (1881) recorded both males in the collections of the Indian Museum, Calcutta, neither of these authors mentioned the female specimen and its fate is unknown.

The collections of the British Museum (Natural History) include a male specimen (in alcohol, its skull extracted), BM(NH) 9.4.4.3, labelled 'Cotype' of *yunanensis,* received from the Indian Museum, Calcutta. That this is one of the original specimens is clear from its labels: it has attached metal tags with the numbers 147 and 107B, and a paper label in its bottle states *"Rhinolophus yunanensis,* cotype. 107B = 147. Hotha, Yunan, 1868. Yunan Exp. (Dr. J. Anderson coll.). Calcutta Mus. [P]." Clearly this is specimen 147 of Dobson (1876: 194) and specimen 107b of Anderson (1881).

The other specimen, 146 of Dobson (loc. cit.) or 107a of Anderson (loc. cit.), remains at the Indian Museum, in the collection of the Zoological Survey of India (Sinha 1973), but is not recorded as a 'cotype' by Khajuria *et al.* (1977). According to Dobson (loc. cit.), specimen 146 is in alcohol, 147 likewise but without skull, and a further number, 148 is allocated to the skull of 147: Anderson (loc. cit.) listed but two numbers, "107a & b, two adult males in alcohol, and the skull of b". However, Andersen has annotated p. 195 of a copy of Dobson (1876) (Monograph of the Asiatic Chiroptera and Catalogue of the species of bats in the collection of the Indian Museum, Calcutta) in the Library of the British Museum (Natural History) to the effect that the entry "without skull" refers to specimen 146 on the preceding line, and that the skull 148 is in fact that of the specimen listed by Dobson as 146.

The archive in London shows that the type specimens of bats in the Indian Museum were loaned to Andersen in 1907-1908 and it seems possible that he found that it was the skull of specimen 146 that had been extracted, that of 147 then remaining in situ. This specimen remained in London and is now BM(NH) 9.4.4.3; its skull bears a label appropriate to that period and may have have been extracted and labelled after its accession to the collections, the Accessions Register indicating merely that it was then a specimen in spirit, not a specimen in spirit with skull. For the present both specimens seem best regarded as syntypes: the measurements given by Dobson (1872, 1879) conform closely to those of BM(NH) 9.4.4.3.

HISTORY. *Rhinolophus yunanensis* Dobson, 1872 has been rarely employed. Soon after proposing the name, Dobson (1874) remarked that *Rhinolophus larvatus* Milne-Edwards, 1872 was most probably identical with *yunanensis,* and reported a specimen (a dried skin, Dobson, 1876: 194) from Tupai Mukh, Meghalaya, collected by the Lushai Expedition. Later, Dobson (1876, 1878) synonymized *yunanensis* and *larvatus* with *Rhinolophus pearsonii* Horsfield, 1851, explaining that the type of the last had been inaccessible for many years in the collection of the Museum of the East India Company, a circumstance that had led to other names being applied to the species. Subsequently, Dobson (1879) gave a further account of the material upon which *yunanensis* was based, but as *R. pearsonii.* Andersen (1905) considered that from published descriptions and figures of *yunanensis* and *larvatus* both were indistinguishable from typical *pearsonii* but certainly different from *R. pearsonii chinensis.* However, Hinton & Lindsay (1927) referred a specimen from the Mishmi Hills, Meghalaya to *yunanensis* with the comment "It is preferable to refer this specimen definitely to *yunanensis*, since its measurements are distinctly greater than for *pearsonii*" and so revived it as a distinct species, while Osgood (1932) pointed out that the status of *yunanensis* was uncertain, although later Ellerman & Morrison-Scott (1951) and Sinha (1973) treated it as a synonym of *R. pearsonii.* More recently the name has been employed by Hill (1975) and Lekagul & McNeely (1977) for specimens from Thailand, and following these authors is listed as a distinct and valid species by Corbet & Hill (1980, 1986) and Honacki *et al.* (1982). McFarlane & Blood (1986) also employed *yunanensis* for specimens from northern Thailand.

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CONSEQUENCES OF SEED DISPERSAL BY BIRDS: A CASE STUDY FROM CENTRAL AMERICA

HENRY F. HOWE[1]

(*With a plate & six text-figures*)

INTRODUCTION

Many ecological questions can only be answered through an analysis of plant and animal interactions. This is best recognized for pollination. Because the vast majority of tropical angiosperms require animals for effective fertilization (Bawa 1974), explanations of floral biology require an understanding of animal perception and behavior (Jones and Little 1983). By comparison, the effective dispersal of viable seed is all but unexplored. Thirty-five to 95% of tree and shrub species in Old and New World tropical forests bear fleshy fruits which vary enormously in size, color, presentation, and structure (Howe and Smallwood 1982). These fruits attract birds and mammals, ranging in size from 10 to 10^7 grams, which may disseminate, digest, or simply destroy seeds (Howe 1986). Beyond biogeographic studies of long-distance dispersal (Ridley 1930), and the classic natural history of birds which scrape the seeds of parasitic mistletoes onto the bark of host plants (e.g. Darwin 1859, Davidar 1978), the ecological implications of these vast arrays of fruit morphology and frugivore function are virtually unknown. Here I explore the local advantages to bird dispersal of a New World nutmeg, *Virola surinamensis* (Rol.) Warb. (Myristicaceae), which are so decisive as to suggest that certain vertebrate dispersal agents can be critical for reproduction of canopy trees.

The objective of my study of *Virola surinamensis* seed dispersal is to explore the mutual benefits gained by fruit-eating animals and this common tree of the forest canopy. The perspective is the study of the *Virola surinamensis* "dispersal system," or the Barro Colorado population of trees and the animals which disseminate, digest, or simply waste its seeds. Each "focus" of field study bears on two central questions. Do *Virola surinamensis* trees secure the services of some fruit-eating animals that have a far greater influence on tree reproduction than others? If so, is dependence on especially efficient dispersal agents mandatory, or can *Virola* "make do" with inefficient dispersal by a variety of species? Answers have much to say about the possibility of coevolution between plants and birds, as well as for the implications of ecological dependence for conservation of small forest reserves.

One focus has been on "reliability" of animal use of plants. "Reliability" implies both frequency and effects of visits to plants (Howe and Estabrook 1977). I document which species ignore *Virola* fruits, which eat them, and whether those that eat them are or are not dispersal agents. The point is to distinguish potentially reliable dispersal agents from animals that digest seeds, and from "fruit thieves" that consume edible pulp, but drop seeds under the tree crown.

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A second focus concerns tree competition for dispersal agents. Some *Virola* trees secure fruit removal, while others do not. Variations in phenology, crop size, and the sizes and rewards of fruits from different trees are explored to uncover the sources of intraspecific differences in fruit removal. The rationale is to pinpoint possible sources of natural selection by dispersal agents through study of variation in a correlate of plant fitness, seed removal (see Maynard Smith 1978). Differential fruit removal implies differential reproduction.

The third and last focus probes the consequences of seed dispersal for seed and seedling survival, and ultimately *Virola* recruitment. Janzen (1970) and Connell (1971) hypothesize that insects or rodents find and eat seeds or seedlings in aggregations under the crowns of fruiting trees, but fail to find those scattered by animals. I confirm this "escape" hypothesis for *Virola surinamensis*, and further show that patterns of seed dissemination by some birds are far more conducive to "seed escape" than those of other species. A continuing study attempts to tease apart the relative importance of "seed escape" and chance dissemination to edaphic conditions suitable for germination and growth.

This short review highlights work in Central America which undoubtedly has important implications for many other "dispersal systems" in the Old and New World tropics. Similar details of natural history for a variety of other dispersal systems will help ecologists and managers understand how frugivory evolved, and how tropical plants and animals can be preserved. A tight bond of dependence between plant and particular bird species makes coevolution possible, whereas a loose bond precludes coevolution (Howe 1984a). Perhaps of more immediate concern, the degree of ecological dependence between plants and birds also has consequences for refuge management (Howe 1984b). Natural reserves without a key dispersal agent may doom one or more tree species to local extinction, just as reserves lacking a key fruiting tree are unlikely to support birds or mammals dependent on it for a critical food resource.

STUDY SITE

My collaborators and I have studied *Virola surinamensis* dispersal since May 1979 at the Smithsonian Tropical Research Institute field station on Barro Colorado Island (9°09′N, 79°51′W), Panama. This island of 15 square kilometers was separated from the mainland by the flooding of Gatun Lake during the building of the Panama Canal in 1914. Approximately two square kilometers on the top of the island are a flat basaltic cap; the remainder is heavily dissected with ravines. The 25 *Virola surinamensis* trees discussed here are scattered throughout a 23 hectare study area in remnants of Old Forest on these ravines and surrounding ridges. The climate is that of seasonal moist forest, with virtually all of the annual rainfall of 2500 mm falling between late April and mid December. Details of climate and other physical and biotic features of the Barro Colorado forest are explored in Leigh *et al.* (1982).

The Barro Colorado forest harbours nearly 400 species of trees (Croat 1978) and over 300 species of birds and mammals (Enders 1935, Willis 1980). Nearly half of the island, cleared and occupied by workmen during the canal construction, is now covered with advanced second growth forest. The other half is mature "old forest," thought to be at least

450 years in age (Foster and Brokaw 1982). Some insectivorous birds have become extinct since the formation of the Panama Canal (Willis 1974), but no frugivorous birds known to eat *Virola* are known to have disappeared in recent decades. Most families of frugivorous birds (e.g. Cotingidae, Cracida, Picidae, Psittacidae, Ramphastidae) and mammals (e.g. Cebidae, Mustelidae, Phyllostomatidae, Procyonidae, Tapiridae) with members large enough to eat *Virola* fruits are well-represented.

BACKGROUND NATURAL HISTORY

Virola surinamensis is a dioecious tree of moist and wet forests from Costa Rica and Panama south to the Guianas and Brazil, with disjunct populations in the Antilles (Croat 1978). This is a canopy species, with reproductives ranging from 19-80 cm dbh and 14-34 m in height. Fruits fit the classic avian dispersal syndrome (van der Pijl 1972). A fibrous capsule dehisces in the morning to expose the unit of dispersal, a grey seed *c.* 2 cm long by 1.5 cm wide, surrounded by a brilliant red laciniate aril 1 mm thick (Plate I; Table 1). Individual trees may be found with fruits during any month of the year, but the greater majority bear fruit between March and September, with a distinct peak in July or August. Crops of individual trees are moderate in size, always falling at the lower end of a continuum of animal-dispersed plants in this forest from the rodent-dispersed *Gustavia superba* (Lecythidaceae) with only a dozen or so compound fruits of 5-50 seeds (Sork 1985), to bird- and mammal-dispersed figs (*Ficus*; Moraceae) with hundreds of thousands of fruits, each containing hundreds to thousands of seeds (Morrison 1978, Wiebes 1979). As a population, *Virola surinamensis* bears fruit each year. As individuals, some trees of this species bear fruits each year, while others miss one or two years in five.

TABLE 1

GENERIC COMPONENTS OF *Virola surinamensis* FRUIT PARTS. THE SAMPLE CONSISTS OF 20 FRUITS FROM A TREE FELLED BY WIND. VALUES ARE FOR DRY MASSES

	Mass (g)	Ash (%)	Protein (%)	Lipid (%)	Carbohydrate* (%)	Energy (kJ/g)
Capsule	2.0	5.4	3.5	8.8	8.5	17.2
Aril	0.8	1.3	3.3	53.2	5.6	28.7
Seed	2.0	1.8	5.5	63.3	2.8	30.8

* Nonstructural carbohydrate.
From Howe and Vande Kerckhove (1981).

The Barro Colorado forest harbours approximately 256 species of resident and migrant birds and 55 species of mammals. Of these, 62 bird species and 18 mammal species eat fruits (Willis 1980 and Enders 1935, respectively). Spider monkeys (*Ateles geoffroyi*) are conspicuous visitors to the trees, and were once thought to be the principal dispersal agents (White 1974). More careful observations show that eight bird species also visit the trees regularly, including the Black-crested Guan (*Penelope purpurascens*), Slaty-tailed Trogon (*Trogon massena*), Rufous Motmot (*Baryphthengus martii*), Collared Aracari (*Pteroglossus torquatus*), Chestnut-mandibled Toucan (*Ramphastos swainsonii*), Keel-billed Toucan (*R. sulfuratus*), and Masked Tityra (*Tityra semifasciata*) (Howe and Vande Kerckhove 1981). Perhaps most notable, several large and abundant frugivores are never seen eating *Virola surinamensis* fruits. For instance, Willis (1980) estimates 250 Purple-throated Fruitcrows (*Querula querula*; 110 g) on the island; one to three pairs were always present in the *Virola* study area. Milton (1977) reports 1200 largely frugivorous Howler Monkeys

(*Allouatta palliata*; 5-8 kg) on Barro Colorado Island; at least three troops with a total of 30-45 animals were always in and near the *Virola* study site. Yet neither of these species, nor several other large and conspicuous frugivores, were ever seen eating *Virola surinamensis* fruits in the course of seven years of field study.

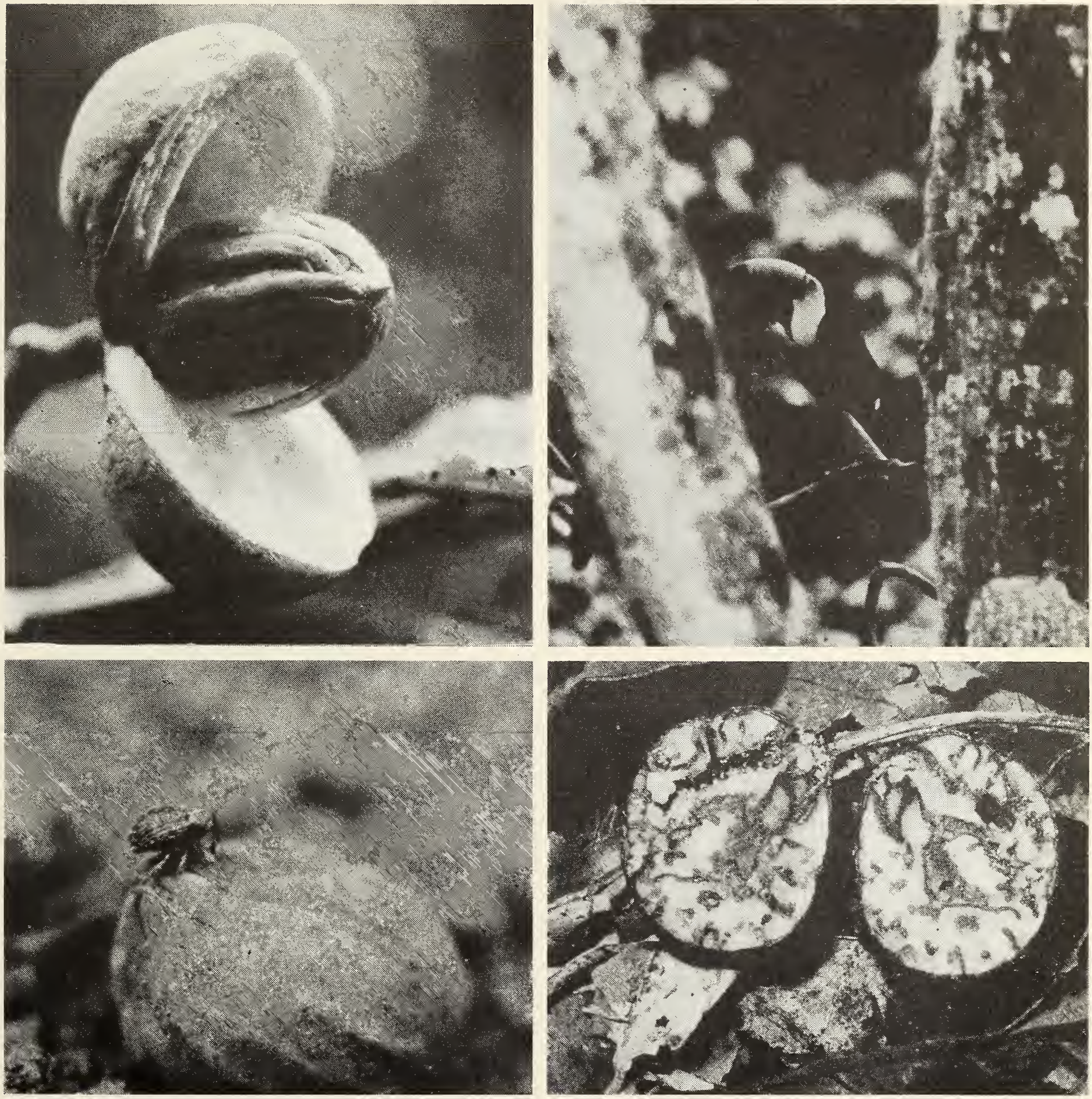
Frugivores swallow the seed and aril, and normally regurgitate (most species) or defecate (*Ateles, Penelope*) the seed intact. Seeds fall to the forest floor and germinate in two or three weeks. Many seeds are eaten by mammals; weevils (*Conotrachelus* New Species; Curculionidae) oviposit on others as the radicle penetrates the seed coat, resulting in destruction of the seed by the larvae (Plate I). Seedlings drop the seed coat at about 12 weeks of age, and persist as surpressed juveniles 10-15 cm high until a tree fall or branch fall allows light to reach the forest floor. Seedlings and saplings are moderately common in the preferred habitat of steep ravines and streamsides, but are rare in the immediate vicinity of fruiting adults.

ANIMAL VISITORS

An initial objective of the *Virola* study is to determine which animal visitors were reliable dispersal agents, and which are not. A "reliable" dispersal agent is one that consistently disseminates viable seeds to sites suitable for germination and growth (Howe and Estabrook 1977). The first step in assessing reliability is to distinguish vertebrate visitors that actually disperse seeds from those that either digest them or drop them under the fruiting tree. A second step is to ensure that intact seeds dropped by different animals are actually viable.

Observations of the activities of dispersal agents are subject to several biases which make much of the published literature uninterpretable. Casual observations rarely reflect actual visitation frequencies; even extensive notes gathered without a systematic method favor large or raucous animals over silent foragers (see Table 2 in Howe 1980). Even more misleading, extensive documentation of animal diets rarely suggests the relative importance of different dispersal agents, from the plant perspective. For instance, a primatologist that follows one monkey species from tree to tree may have a false impression that it is a principal dispersal agent of the plant, when other birds or mammals actually remove more viable seeds or take them to sites more favorable for germination and growth.

Quantitative data have their own biases. Censuses, timed throughout the day or night, can provide comparable quantitative data for several to many individual trees over several years with a minimum of effort. Even careful censuses, however, disproportionately list frugivores with long visits over those that stay only a short time (Howe 1980). Unless the number of fruits eaten bears a constant relation to visit time, for all species foraging in the tree, a census cannot estimate relative importance of different dispersal agents to a tree species. Finally, extended watches of select trees permits an evaluation of frequency of fruit use by different animal species, and allows an observer to tabulate the numbers of fruits consumed, dropped, regurgitated, or defecated for visits by each frugivore. But such observations are so time-consuming that only a few trees can be watched; frugivores that visit some trees may ignore others of the same species. Finally, observations at the beginning or end of a season often distort interpretations because visitors common during some months are entirely absent in others (Howe 1977). A



Above left: *Virola surinamensis* fruit at dehiscence. *Above right*: Keel-billed Toucan (*Ramphastos sulfuratus*). *Below left*: *Conotrachelus* weevil on germinating *V. surinamensis* seed. *Below right*: Fatal damage of *Conotrachelus* larva on *V. surinamensis* seed 8 weeks after fruit fall. See Howe *et al.* (1985).

"reliable" dispersal agent must be consistent throughout a season, as well as from one season to another.

Birds and mammals visiting *Virola surinamensis* trees were evaluated with a combination of extended observations and censuses. Watches of five hours duration documented frugivore activity in detail at a limited number of trees; censuses allowed comparisons of disperser assemblages across years.

Extended watches during 1979 involved 40 hours of observation in five hour blocks at each of eight trees. Observations at each tree were between 0600 and 1100 hours in the morning, and were spaced throughout the fruiting season. Two observers alternated five hour blocks. Censuses involved 15-30 second scans of *Virola* crowns with binoculars. Each census walk took one hour, covered 1.5 km, involved 19-22 fruiting trees, and were undertaken between early June and late August in 1979, 1980, 1981, and 1982. Five hours between 0600 and 1700 were randomly selected for each day from a random-number table (Rohlf and Sokal 1969); these censuses were walked two days each week.

Extended watches during daylight hours revealed that only seven of 62 frugivorous birds, and one of 18 frugivorous mammals, consistently ate *Virola surinamensis* fruits (Table 2). Trees were devoid of animals for most of the day, but experienced heavy use early in the morning and during periodic spates of activity (Fig. 1). Extended watches in the morning sample the period of greatest use of *Virola* trees by animals, although censuses later

TABLE 2

NUMBER OF FRUGIVORES OBSERVED EATING *Virola surinamensis* fruits. CENSUSES INVOLVED 180 ROUNDS OF 19 TREES (3420 SCANS); WATCHES INCLUDED 40 H OF OBSERVACION AT EACH OF 8 TREES (320 H)

Family Common name (binomial; weight)	Sightings (N)* Censuses	Watches
Cracidae		
Crested Guan (*Penelope purpurascens*; 2000 g)	9	11
Trogonidae		
Slaty-tailed Trogon (*Trogon massena*; 145 g)	10	82
Motmotidae		
Rufous Motmot (*Baryphthengus martii*; 185 g)	12	97
Ramphastidae		
Collared Aracari (*Pteroglossus torquatus*; 229 g)	7	16
Chestnut-mandibled Toucan (*Ramphastos swainsonii*; 640 g)	47	118
Keel-billed Toucan (*Ramphastos sulfuratus*; 339 g)	59	112
Cotingidae		
Masked Tityra (*Tityra semifasciata*; 84 g)	19	48
Cebidae		
Spider monkey (*Ateles geoffroyi*; 6000 g)	55	33

* Distributions of sightings from the two methods differ ($X^2 = 37.7$, 7 df, $P < 0.005$). From Howe and Vande Kerckhove (1981).

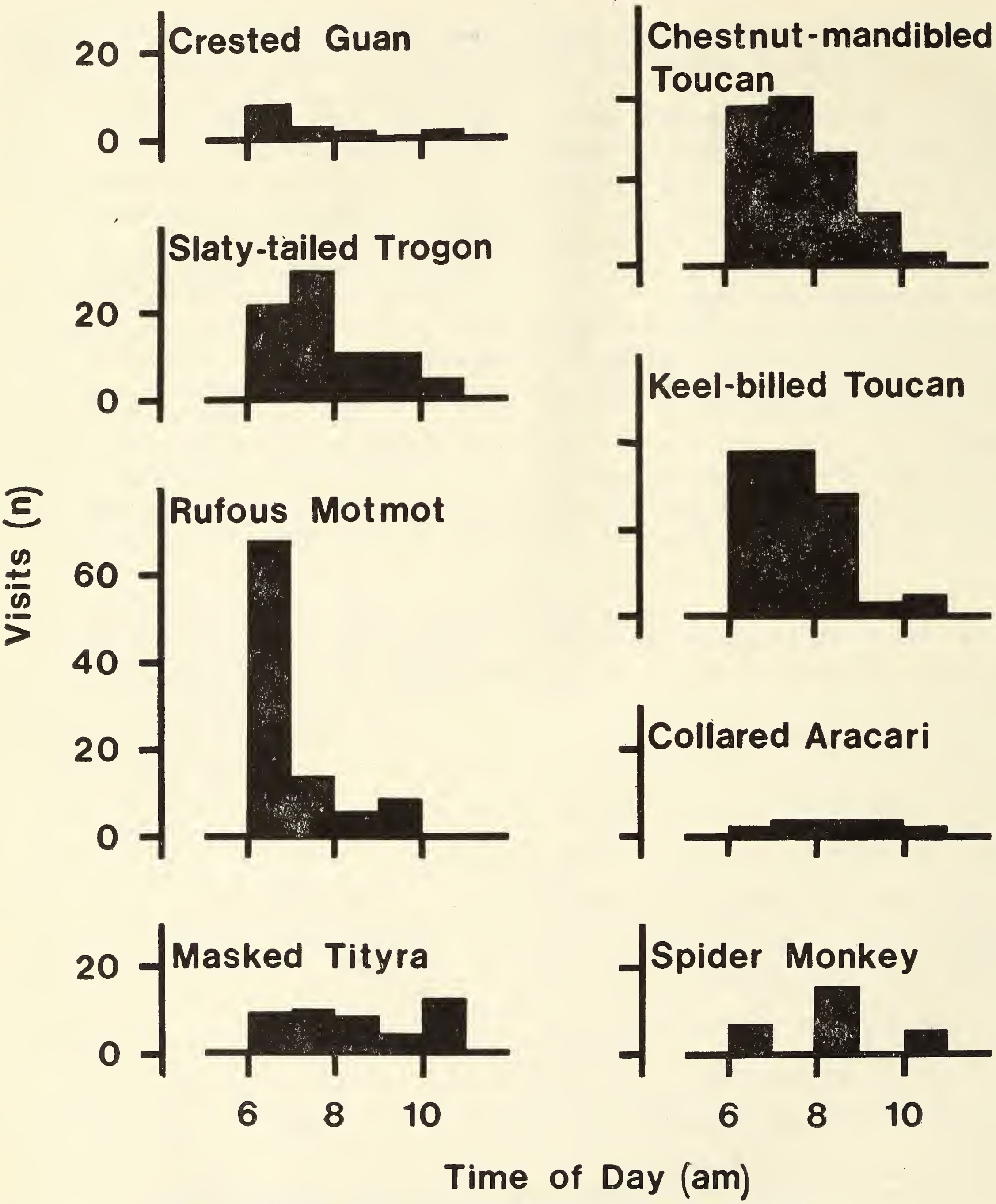


Fig. 1. Visitation times of eight common frugivores seen foraging at *Virola surinamensis* during 40 h of observation at each of eight trees. (Howe and Vande Kerckhove 1981).

TABLE 3

RELATIVE CONTRIBUTIONS TO DISPERSAL AND WASTE OF ARILLATE SEEDS HANDLED BY FRUGIVORES VISITING *Virola* TREES. "WASTE" INCLUDES SEEDS DROPPED UNDER TREE CROWNS AS WELL AS THOSE FACING INEVITABLE MORTALITY IN FECAL CLUMPS OF MONKEYS (SEE TEXT)

		Seeds per visit		Estimates of seeds		Total handled	
Common Name	Sightings (N)	Dropped ($\bar{x}$)	Removed ($\bar{x}$)	Wasted (N)	Dispersed (N)	Wasted (%)	Dispersed (%)
Black-crested Guan	10	0.0	5.1	0	51	0	9
Slaty-tailed Trogon	81	0.0	0.7	0	56	0	10
Rufous Motmot	97	0.1	0.8	10	78	2	14
Collared Aracari	16	0.0	0.3	0	5	0	1
Chestnut-mandibled Toucan	119	0.1	1.7	12	202	2	35
Keel-billed Toucan	112	0.1	0.4	11	45	2	8
Masked Tityra	40	0.7	0.0	28	0	5	0
Spider Monkey	29	1.2	1.3	54*	19†	9	3

* Includes seeds dropped as well as those doomed to sibling competition in droppings.

† Estimated number of seeds dispersed = number of droppings = number of seeds removed/number of seeds per dropping.

From Howe and Vande Kerckhove (1981).

showed that some activity extends through the afternoon and into the evening hours.

Rate of fruit consumption and waste per visit could be tabulated when a visitor was in continuous view from entry to departure. These complete records show the peril of treating visits of different species as equivalent, from the plant perspective (Table 3). For instance, two large toucans, the Chestnut-mandibled and Keel-billed, had equivalent visitation rates but different rates of fruit removal. Because the larger Chestnut-mandibled Toucan foraged methodically and often ate one to five fruits in a visit, while the smaller and peripatetic Keeled-bill Toucan rarely ate more than one or at most two fruits per visit, the large bird was nearly four times as likely to remove *Virola* seeds as the smaller. Chestnut-mandibled Toucans did not actively chase smaller species, as they do at some other species of trees (Howe 1977, 1981; see Pratt 1983). Likewise spider monkeys once thought to be primary dispersal agents of this tree, actually ate few seeds and knocked down more than they consumed (cf. White 1974). One small cotinga, the Masked Tityra, was a "fruit thief" because it peeled off arils without consuming or otherwise removing seeds. The large size of the fruit undoubtedly limited the tityra's ability to swallow the seeds. This bird is an effective dispersal agent of the much smaller-seeded *Virola sebifera* (Howe 1981) and of other small-seeded trees (Howe 1977, Howe and De Steven (1979).

Censuses revealed the same assemblage of dispersal agents, throughout the day and season for four years (Table 4). A comparison of watch and census data for 1979 shows that visitors which snatch one seed at a time are under-represented in census data (e.g. trogons and motmots), while monkeys that forage slowly, rest, and even sleep in the trees

TABLE 4

ANNUAL DIFFERENCES IN CENSUS COUNTS OF FRUGIVORES AT 19-23 *V. surinamensis* TREES (STANDARDIZED TO 3400 TREE CHECKS EACH)*

Frugivore	Number of sightings			
	1979	1980	1981	1982
Black-crested Guan	7	6	14	15
Slaty-tailed Trogon	7	12	11	9
Rufous Motmot	13	4	6	8
Collared Aracari	7	8	16	4
Chestnut-mandibled Toucan	31	38	40	36
Keel-billed Toucan	52	52	39	22
Masked Tityra**	18	48	20	11
Spider Monkey	50	57	91	38
White-faced Monkey**	0	8	31	36
Total	185	233	268	179

* From 1980 to 1982, 4 trees were added to the 19 censused in 1979.

** Not dispersal agents.

Augmented from Howe (1983).

are over-represented (Table 2). Annual variation in assemblage character can be seen in comparing census data from one year to the next. Of special note is the addition of white-faced monkeys (*Cebus capuchinus*) from 1980 through 1982. This species is a fruit thief when it nips the base of the aril and drops the seed, and is a "seed predator" when it peels and discards the aril and eats the seed. White-faced monkeys are apparently not consistent dispersal agents of *Virola surinamensis.*

Night censuses were also conducted between 1930 and 2100 hours, at the peak of nocturnal frugivore activity (Glanz 1982), with an electric spotlight and binoculars. Nocturnal activity was negligible during two years, but substantial during 1980 and 1982 (Table 5). Of the four species of nocturnal mammals seen, only the kinkajou (Procyonidae) was a frequent visitor.

TABLE 5

ANNUAL DIFFERENCES AT NIGHT CENSUS COUNTS AT TWENTY-TWO *V. surinamensis* TREES (STANDARDIZED AT 308 TREE CHECKS)

Frugivore	Number of sightings			
(Binomial)	1979	1980	1981	1982
Opposum (*Didelphis marsupialis*)*	0	1	0	0
Night Monkey (*Aotus trivirgatus*)	0	4	0	0
Coatimundi (*Nasua narica*)*	0	1	0	0
Kinkajou (*Potos flavus*)	0	18	3	14

* Not dispersal agents.

Augmented from Howe (1983).

All members of this disperser assemblage defecate or regurgitate viable seeds, except the white-faced monkey. Seeds covered with an aril rot in the field, as they do on top of the soil in a screened growing house (Table 6). Those with arils removed by me or by regular dispersal agents germinate. Seeds are not scarified, but they must be free of a moldy aril to germinate.

TABLE 6

GERMINATION OF *Virola surinamensis* PROCESSED AND NOT PROCESSED BY FRUGIVORES

Treatment	Planted (N)	Germinated (N)*
Aril intact	30	0
Regurgitated by toucans	30	26
Arils removed by investigator	30	28
Defecated by guans	10	9
Defecated by spider monkeys	24	17

* Observed for 15 wk; germination occurred in 2-3 wk.

From Howe and Vande Kerckhove (1981).

Finally, field observations give some hints as to the disposition of seeds. Birds which have eaten *Virola* fruits generally fly to a non-fruiting tree nearby, where the aril is stripped and the seed regurgitated in 10-25 minutes (most species) or defecated in 30-45 minutes (guans). Perch sites vary in distance from fruiting *Virola* trees (Table 7). Smaller trogons and motmots leave approximately 80% within 20 m of the feeding tree, whereas much larger guans and toucans take at least half > 40 m away. Spider monkeys scatter seeds widely in groups of two to four per dropping. Kinkajous defecate viable seeds, but often leave them in heaps directly under hollow tree cavities where they sleep during the day. Four years of observations at one such hollow showed >> 500 *Virola* seeds each season, but no seedlings; all seeds were killed by insects and rodents as they germinated.

In sum, only a small proportion of fruit-eating animals on Barro Colorado Island eats *Virola* fruits. Of these, only the Chestnut-mandibled Toucan is both a consistent visitor and takes most seeds a substantial distance from fruiting trees. Other species are potential dispersal agents, but are less reliable from the plant perspective because they eat relatively few fruits, are wasteful foragers (i.e. spider monkeys), drop seeds near *Virola* crowns (motmots, trogons), or defecate seeds in large piles from which few or none survive (kinkajous). In the Barro Colorado forest, three large birds are the best potential dispersal agents and only one, the Chestnut-mandibled Toucan, actually does the job well.

TABLE 7

MINIMUM ESTIMATES OF THE PERCENTAGES OF SEEDS DROPPED BY BIRDS AT DIFFERENT DISTANCES FROM *Virola surinamensis* TREES

	Distance from crown edge (m)					
Bird (N)*	Under tree	0-9	10-19	20-29	30-39	>40
Crested Guan (17	0	5	37	0	5	53
Slaty-tailed Trogon (38)	8	53	24	10	0	5
Rufous Motmot (17)	12	76	6	6	0	0
Keel-billed Toucan (32)	0	6	16	22	0	56
Chestnut-mandibled Toucan (48)	23	4	4	8	8	52

* Each carry refers to a seed taken from a tree to some point at which it is regurgitated (most birds) or defecated (i.e. guans).

Augmented from Howe and Vande Kerckhove (1981).

COMPETITION FOR DISPERSAL AGENTS

Dispersal agents are in limited supply if many fruits remain undispersed; differences in fruit removal among plant species suggest that some compete for fruit-eating animals better than others (McKey 1975). Similarly, a high variance in number or proportion of fruits removed from trees of the same species suggests that some individuals vie more effectively for dispersal agents than others (Howe and Estabrook 1977). To determine the likely sources of natural selection, one must evaluate sources of variance in dispersal. This distinguishes chance differences in fruit removal from those which might be under the control of parent trees, and consequently subject to natural selection.

An evaluation of "dispersal success" requires estimates of both the number of fruits produced and the number removed by animals for each *Virola surinamensis* individual (see Howe 1980, Howe and Vande Kerckhove 1981). These estimates were achieved from 1979 through 1983 with 1 m² fruit traps constructed of plastic (PVC) tubing, with plastic insect netting fastened to a square frame with nylon fishing monofilament. Each square was raised off of the ground 0.5 to 1 m, depending on topography. Traps were placed in a randomized design (coordinates chosen from a random number table; Rohlf and Sokal 1969) in quarter circle sampling areas under each tree crown, where the radius of the circle (r) was the distance from the trunk to the crown edge. A sum of four sample areas, each $0.25 \pi r^2$, defined the total area under of crown of each tree. One to 10 fruits traps were randomly assigned to each quarter, with the intention of sampling 10% of the crown area. In practice, 12±4% S.D. of the crown areas actually were sampled with 5-18 (10±4 S.D.) traps per tree. A unique estimate of individual fruit production is possible by dividing the number of items (e.g. capsules or seeds) caught by the proportion of the crown sampled (e.g. 507 capsules/0.125).

Fruit traps sample empty capsules and undispersed seeds that fall directly under the tree crowns. The difference between the two estimates the number of seeds taken away. Capsule debris shows that individual *Virola surinamensis* trees produce as few as 100 to more than 30,000 fruits in a season, with the median individual crop ranging from 2,000 to 8,600 (Table 8). Such fecundity is much lower than that of many forest trees, such as figs (*Ficus*), but apparently satiates available dispersal agents; only 40 to 65% of the fruits in this population are removed by animals in a given year (Table 9). A plot of census data (previous section) against individual production over the 1979 season suggests one reason why fruits are wasted; the number of individual birds and mammals censused at a tree increases with its crop size ($r^2 = 0.62$, $P < 0.0005$), but the number of species does not ($P>0.1$). Unlike some trees with smaller fruits (e.g. *Casearia*, Howe and Vande Kerckhove 1979; *Tetragastris*, Howe 1980), *Virola*

TABLE 8

ANNUAL VARIATION IN FRUIT PRODUCTION AT *V. surinamensis* TREES

Year	N	Range	Median (25-75% quartiles)
1979	17	214–10412	2082 (1326–3584)
1980	25	428–31006	8579 (4161–12493)
1981	25	638–26163	3990 (2687–6687)
1982	25	78–14075	5612 (1945–8008)
1983	25	92–14450	2420 (509–5333)

Augmented from Howe (1983).

TABLE 9

ANNUAL VARIATION IN THE PERCENTAGE OF FRUITS TAKEN FROM 15 *V. surinamensis* TREES

Year	Range	Mean (± S.D.)
1979	13-91	60±20
1980	24-73	46±15
1981	40-77	59±10
1982	13-64	41±12
1983	27-90	65±16

Augmented from Howe (1983).

surinamensis does not have a virtually infinite assemblage of potential dispersal agents to draw upon. Census data show that large and small trees use the same small "gallery of connoisseurs," and fruit traps suggest that this limited coterie of species often has more fruits available than can be consumed.

Data from fruit traps also suggest intense competition for dispersers among trees within the *Virola* population (Table 9). As many as 91% or at few as 13% of the fruits are taken by animals, leaving 9% to 87% directly under the tree crown. Five or six times the percentage of fruits taken from some trees are taken from others, sometimes in the same stand. Average removal is low enough to indicate disperser limitation, while variance in removal is high enough to suggest active competition for dispersal agents. If consistent over the lives of these trees, such differences would translate into a differential dispersal success of tens or even hundreds of thousands of seeds.

Trees with large crops virtually always disperse more seeds than those with small ones, indicating an ultimate *numerical* advantage in high fecundity within a tree population (Howe and Vande Kerckhove 1981). But small trees grow into large ones; the lifetime dispersal of a tree is the sum of the proportion of fruits taken in each season multiplied by the number of fruits available in each season. An evaluation of the *proportional* advantage in fruit removal that some plants have over others of their species provides a glimpse into differential reproduction during a five-year time frame.

Firstly, crop size does not influence the proportion of fruits removed by animals. If birds had difficulty finding small trees and easily found large ones, the proportion of fruits taken should increase with crop size. If birds had difficulty finding small plants and were satiated at large ones, a curvilinear relationship between proportion taken and crop size would exist. Neither a linear nor curvilinear relationship holds, or even approaches statistical significance (Howe 1983). Whatever influences proportional dispersal is independent of individual crop sizes.

Secondly, the nutrient content of arils does not influence dispersal. Tremendous variation does occur from tree to tree in the nutritive content of arils (Table 10). But none of these differences are significantly correlated with the proportion of or the absolute number of fruits taken from different trees (Howe 1983). These results might reflect coarse techniques that involve composite analyses of several arils from each tree. Results are so overwhelmingly negative, however, that it seems safe to conclude that birds simply do not discriminate intraspecific differences in aril composition, or that their discrimination is so subtle that it is easily obscured by other sources of variance in the data (see Sorensen 1981). My colleagues and I have noticed that spider monkeys (*Ateles*) consistently smell and reject more than half of the fresh fruits that they encounter, and *Virola* arils from some trees are far too astringent for

TABLE 10

PERCENTAGE OF ARIL COMPONENTS FOR INDIVIDUAL *Virola surinamensis* TREES, IN PERCENT DRY MASS*

	Trees (N)	Range (%)	Mean (%)	SD (%)
Ash	17	0.9-1.3	1.1	0.2
Protein	17	1.6-3.6	2.5	0.7
Lipid	16	46.0-86.2	63.1	14.0
Free carbohydrate	17	6.6-12.6	9.2	1.5

* Energetic content for arils from 17 trees ranged 26.2-29.5 kJ/g (27.9±0.8).

From Howe and Vande Kerckhove (1981).

me to eat (Howe and Vande Kerckhove 1981). This fruit is apparently protected against some primates, which are often exceedingly wasteful foragers (Howe 1980). Possibly, volatile compounds not analyzed in the laboratory would account for some variation in fruit removal by birds (see Sorensen 1983).

Finally, birds might discriminate between trees with different investments in edible aril, as compared with bulky and indigestible seeds. Birds are aerodynamically stressed if they must carry much more than 5% of their body weight, and indigestible *Virola* seeds averaging 3-4 g in weight would seem to be unwelcome ballast. In fact, *Virola* seeds vary four-fold in weight; 78% of this variance is attributable to differences between trees, and 22% is attributable to differences within trees (Howe and Richter 1982). A plot of the proportion of fruits removed against the average weight of aril plus seed from different trees shows a clear negative correlation; dispersal agents tend to avoid trees with heavy fruits (Fig. 2). A further test shows that the proportion of fuits taken is strongly correlated with the average ratio of aril to seed for a sample of trees (Fig. 3A), and is negatively correlated with the mean weight of seeds from individual trees (Fig. 3B). For the year shown, the aril/seed ratio accounted for 52% of the variation in dispersal success. Dispersal agents are capable of assessing the profitability, or the energy benefit as contrasted with the energy cost, of eating *Virola* fruits from different trees.

The question arises whether this potential for selection on trees is consistent from year to year. A repeated analysis confirms that differential fruit removal occurs, but differs in magnitude (Table 11). Highly significant correlations between proportion taken and the aril/seed ratio occurred during 1979 and 1983, when *Virola surinamensis* crops were small (medians under 2,500 fruits per tree) and fruits were scarce in the population. Less significant results were obtained for other years, when *Virola* fruits were more plentiful. This implies that dispersal agents seek out the "best" trees when fruits are scarce, but do not bother to find them when fruits are superabundant in the forest. This interpretation gathers support from an *ad hoc* analysis of fruit depletion in 1980 and 1981, when weak correlations existed between fruit removal and the aril/seed ratio. Trees bearing fruit early in those seasons, when fruit was generally scarce, showed a strong positive correlation between dispersal and aril/seed ratio; the same trees lost those correlations in mid and late season when fruits were far more common (Howe 1983). Apparently, *Virola* trees are potentially under selection by dispersal agents when fruits are scarce but not when fruits are common, whether the time scale is an entire season or simply a few weeks of dearth. But there is no particular advantage to large aril or small seed size when fruits are so superabundant that birds need not travel far to find them.

In sum, natural variation in dispersal success can in part be explained by fruit charac-

TABLE 11

CORRELATION OF PROPORTION OF SEEDS REMOVED AND THE RATIO OF ARIL TO SEED WEIGHT IN *V. surinamensis*

Year	Trees (N)	r	Significance ($p \leqslant$)*
1979	17	0.72	0.001
1980	25	0.37	0.06
1981	25	0.37	0.06
1982	22	0.43	0.05
1983	17	0.55	0.01

* 2 tail test.

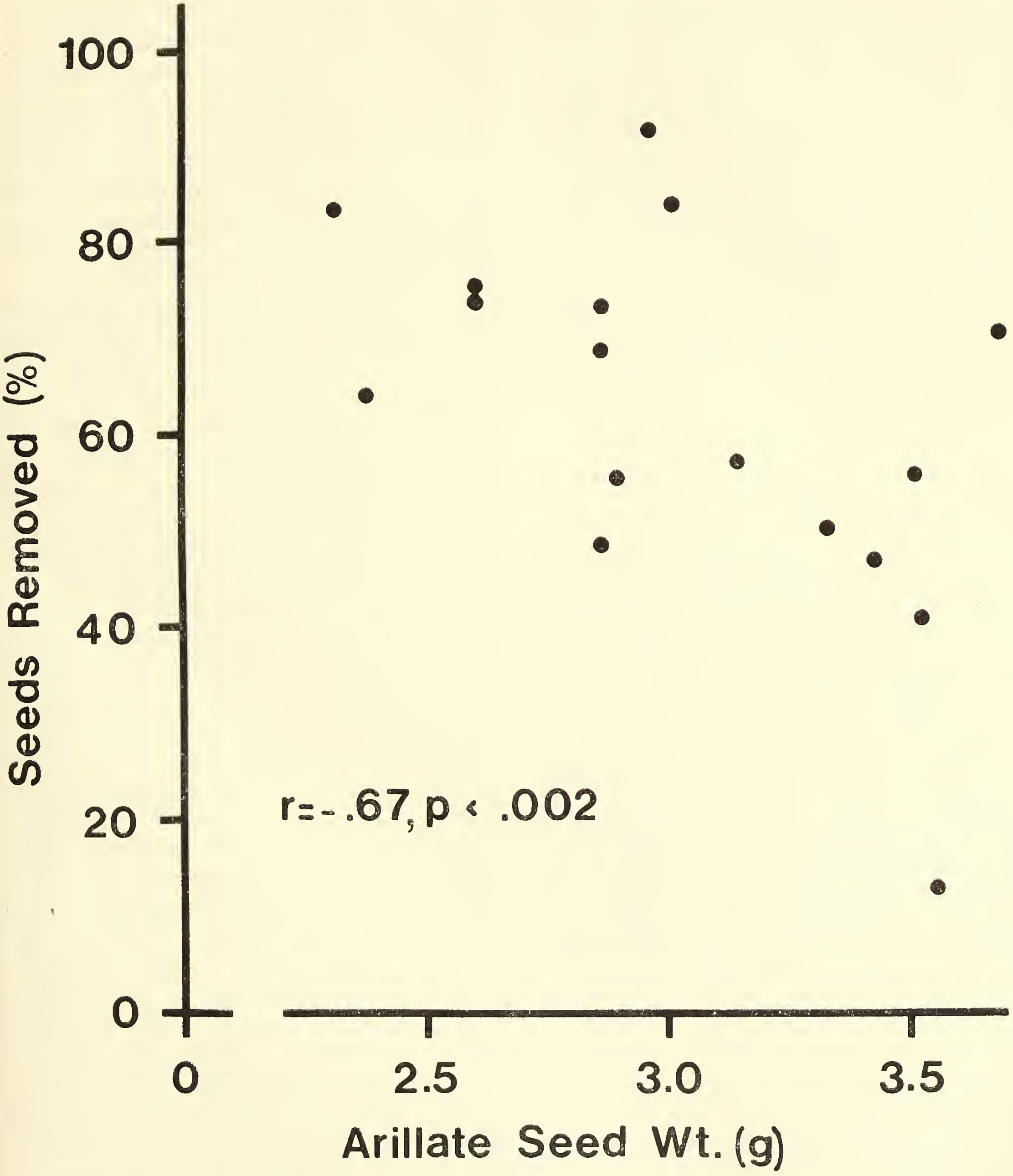


Fig. 2. Seeds taken by animals plotted against the mean dry weight of seed plus aril (Howe and Vande Kerckhove 1981).

teristics. Birds sensitive to weight avoid heavy fruits when they must fly substantial distances to feed. Under such conditions of scarcity, they prefer *Virola* trees with an unusually high ratio of nutritious pulp to seed ballast. Other sources of variance on which selection might act are not yet clear. Proximity of productive neighbors can sometimes depress fruit removal (Manasse and Howe 1983), and highly destructive monkeys can obscur relationships which might otherwise show through (Howe 1983). At present, however, neighborhood effects and monkey depredations are best considered stochastic effects on fruit removal.

CONSEQUENCES OF SEED DISPERSAL

What are the consequences of frugivory by different dispersal agents for *Virola surinamensis* reproduction? Most visitors regurgitate or defecate viable seeds (Table 6), but tend to drop them at different distances from fruiting *Virola* trees (Table 7). Do small differences in dispersal distance have consequences for seedling establishment and growth, as Janzen (1970) and Connell (1971) speculated?

Natural seed fall in *Virola surinamensis* is, as is typical of other plants in central Panama (Augspurger 1983), characterized by high and variable densities of seeds under fruiting trees, and very low densities beyond the edge of the tree crown (Fig. 4). A rain of seeds untouched or knocked down by animals ensures that seed densities under the crown can be over 1000 times as high as densities only 10 metres from the base of a tree. In fact, seed fall beyond the crown can only be estimated with sampling wedges (10°) that dramatically increase the area sampled as one moves away from a tree; the dilution of seeds that occurs at a rate of $\pi\ r^2$ as one moves radially from a central point makes scattered seeds very difficult to find. The natural seed fall in this species offers ample potential for devastating insect or rodent attacks on densely clumped seeds or newly germinated seedlings. The far lower densities even a few metres from the trunk might, as Janzen (1970) suspected, make local dispersal extremely important. The question asked here is, simply, whether a seed dropped directly under a *Virola* crown has a different probability of survival than one dropped at some specified distance away.

The "seed escape" hypothesis was tested with experimental plantings of seeds, germinating seeds, and established seedlings at 5, 15, 25, 35, and 45 m from trunks of fruiting *Virola* trees. Practical considerations prevented one "clean" experiment. Rates of seed and early seedling death were so high that 250,000 seed plantings would have been required to produce as few as 500 yearlings. As an alternative, my colleagues and I placed three cohorts in randomly chosen spots on circles at each distance. The first placement, in 1982, involved 3,400 seeds in groups of 40 scattered on each of the five circles, for each of 17 female trees. Forty seeds at five metres around each of 13 male *Virola* trees (a total of 400 seeds) provided a partial control for possible effects of inevitably higher densities of experimental seeds in small circles under females. Males do not normally have seeds under or near them. Another planting of seeds germinated in a screened growing house was made at six weeks in 1983. Space in the growing house reduced this sample to 2,000 germinating seeds, which were placed in sets of 25 on the perimeters established in 1982 for 13 females and 15 males. The experiment was repeated for fully established 12 week old seedlings in 1984, using 25 plants for each perimeter at 7 female and 7 male trees. In each year, plants were checked each two weeks after planting.

Overall, this series of experiments provide a dramatic confirmation of the prediction that local dispersal should help seeds escape disproportionate mortality near parent trees. Fewer than 20% of the seeds survive the first six weeks, ranging from < 4% under the crowns to 16% at 45 m (Fig. 5). During the second experiment, survival was 1% under the crown and approximately 11% at 45 m (Fig. 6). Overall, over 99% of the seeds and seedlings die within the first 12 weeks after fruit fall. Even with such high overall mortality, there is a 10 fold advantage to dispersal only 15 m, as compared with 5 m, and more than a 40 fold advantage to dispersal 45 m. Mortality under female trees is far higher than that under male controls. In 1983, as many seeds survived to 12 weeks 5 m from males as survived 45 m from females. This suggests that effects of aggregating seeds under trees in the experimental design are minor compared clumping produced by natural seed fall (Fig. 4).

Major sources of mortality include inges-

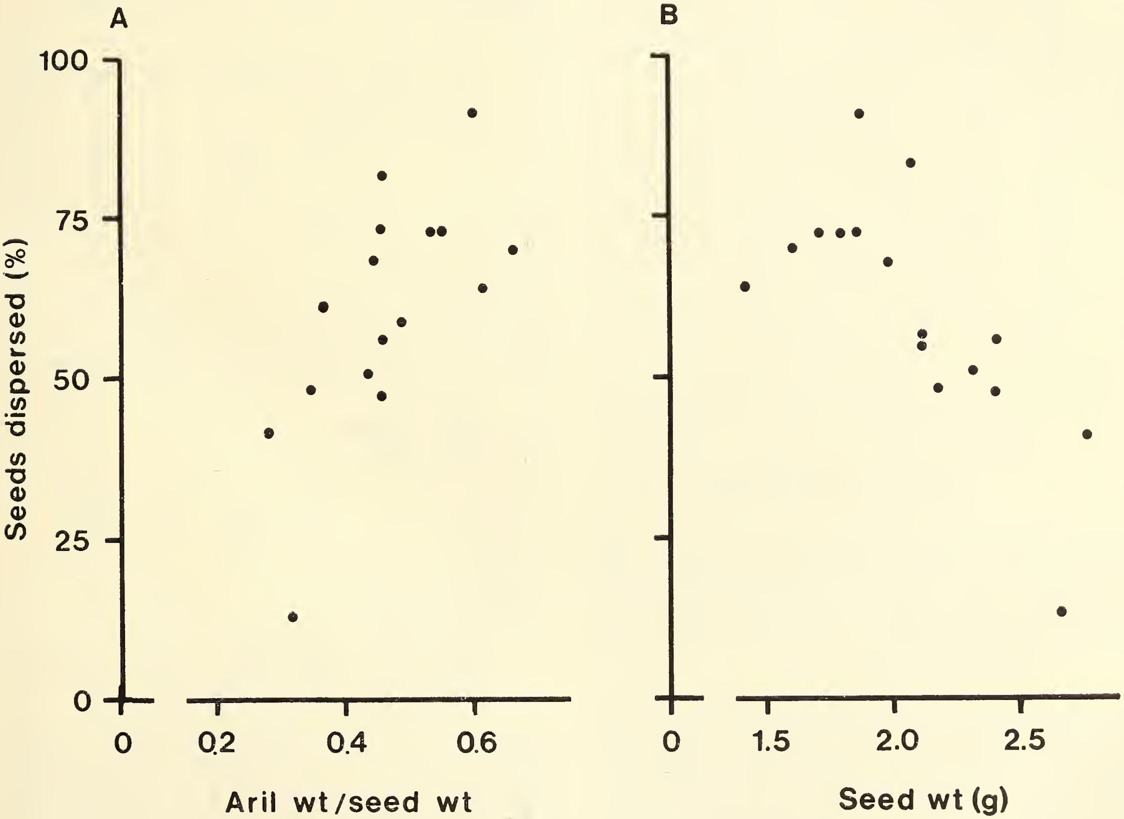


Fig. 3. (A) Strong positive correlation of the proportion of seeds taken from individual trees and the mean ration of dry aril to dry seed weight at each tree ($r = 0.71$, $P < 0.001$). (B) Strong negative correlation between the proportion of seeds taken and seed dry weight ($r = -0.77$, $P < 0.0002$). See Howe and Vande Kerckhove (1980).

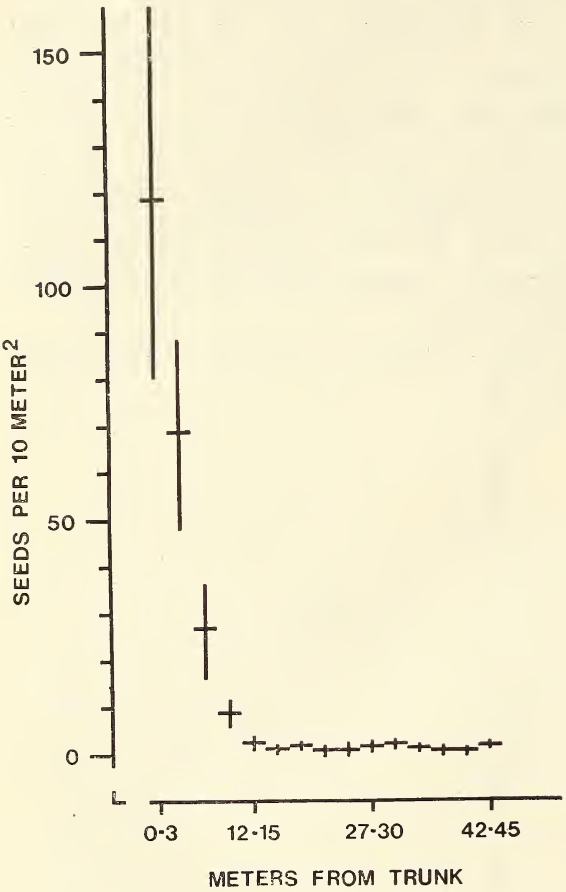


Fig. 4. Natural seed fall around five fruiting *Virola surinamensis* trees. Seeds were sampled over 2 wk for each tree by randomly directed wedges encompassing 707 m^2. Means ± 1 standard error. See Howe *et al.* (1985).

tion by mammals, such as paca (*Agouti paca*) and deer (*Dama virginiana*), and larval feeding by a curculionid weevil (*Conotrachelus*, new species; Plate I). During the first 12 weeks, approximately half of the mortality is attributable to mammals, and half to the weevils. Interestingly, disproportionate mortality near fruiting trees is almost all due to the weevil, which oviposites on seeds from germination at 2-3 weeks through 8-10 weeks of age. This is easily seen during the first two weeks after fruit fall, when nearly half of the seeds are eaten by mammals, with no noticeable effect of distance from the fruiting trees (Fig. 5). Dramatic effects of distance are evident from

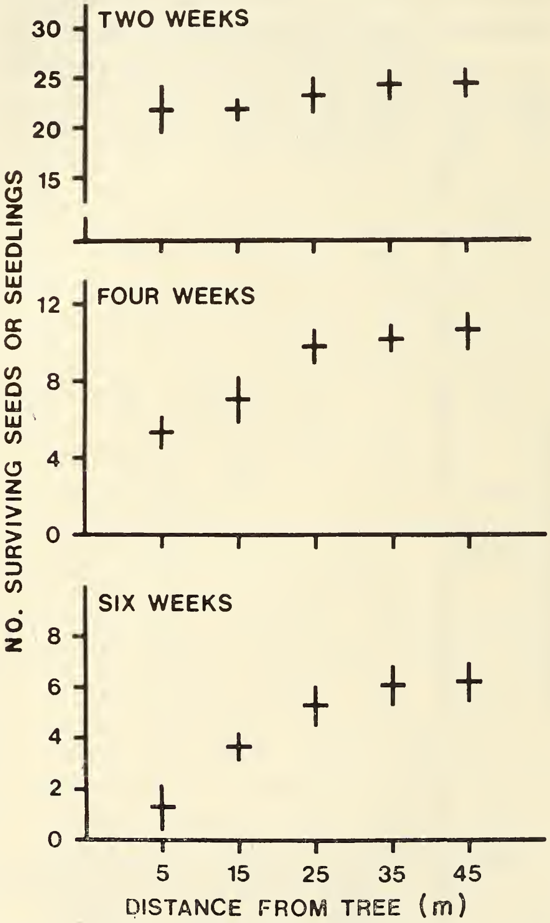


Fig. 5. Survival as a consequence of distance from 17 fruiting *Virola surinamensis* trees during the first 6 wk after fruit drop. Two hundred freshly fallen seeds were placed in concentric rings around each tree, with 40 seeds per ring per tree. Means ± 1 standard error. Patterns are significant at four weeks ($F = 5.96$, $P < 0.0005$) and six weeks ($F = 9.02$, $P < 0.0001$). See Howe *et al.* (1985).

4-12 weeks, when *Virola* seeds and young seedlings are vulnerable to *Conotrachelus.* A more detailed investigation shows that mammals, if anything, eat more seeds and seedlings away from *Virola* trees than under them (Howe *et al.* 1985). There is no evidence that rodents bury these seeds. Seedlings are not found pushing up from the subsoil, and piles of seed dust testify to direct consumption. Some rodents thought to play a major role in seed dispersal, such as the agouti (*Dasyprocta punctata*; see Janzen 1970), eat *Virola surinamensis* arils, but neither eat nor transport the seeds (Larson and Howe, in press).

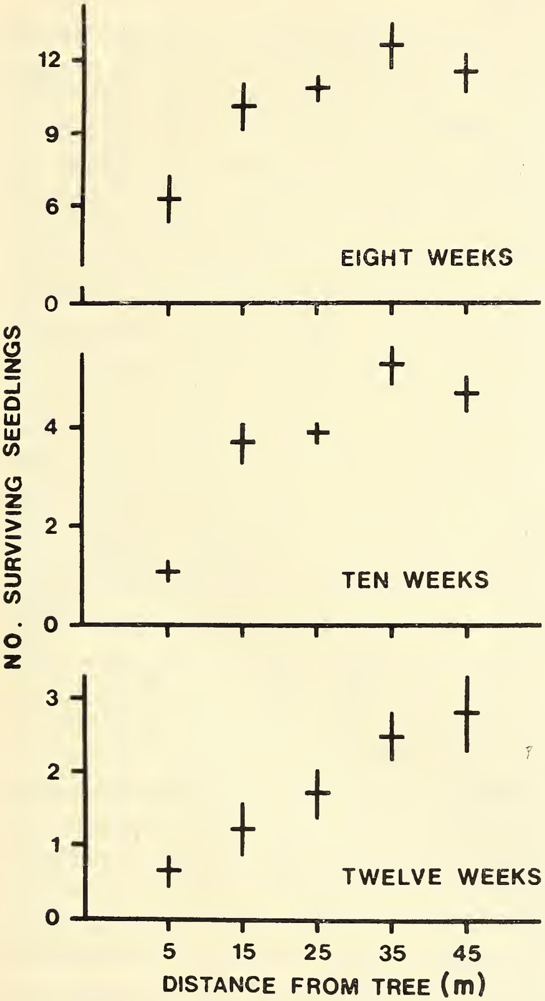


Fig. 6. Survival as a consequence of distance from 13 fruiting *Virola surinamensis* trees. One hundred and twenty-five germinating seeds 6 wk after fruit drop were placed around each tree in the design used for Fig. 4, but with 25 seeds per ring per tree. Means ± 1 standard error. Patterns are significant at each age (Friedman's tests; $X^2_r = 11.9$, 27.7, and 16.6, all 4 df, all $P < 0.02$ or better). See Howe *et al.* (1985).

While early seed and seedling mortality show a 40 fold advantage to short-distance seed dispersal away from fruiting trees, patterns of survival and mortality after independence from parental seed stores show no such advantage. Approximately 60% of the 12 week old seedlings planted in concentric rings around fruiting *Virola* trees in 1984 died within six months; within 12 months 70% were dead. This mortality appears to be random with respect to distance from fruiting trees, although markedly non-random with respect to light and edaphic conditions within the forest ravines inhabited by the species. For instance, seedlings surviving the first dry season were those planted on steep slopes (36±13° S.D.). This might indicate intolerance of desiccation; Rundell and Becker (manuscript) find higher water stress in seedlings on flat than steeply sloping ground. Similarly, this species is shade tolerant, but grows best under a broken canopy (Howe *et al.* 1985). The combined effects of slope, light, and death or decapitation by browsers are currently under investigation.

In short, a strong early advantage to escape from high seed and seedling densities does favor local seed dissemination by birds. Because toucans carry seeds further than small trogons or motmots, the larger birds are from the plant perspective four to 40 times as effective as the smaller species. This effect is entirely due to devastating attacks by weevils that infest otherwise viable seeds and seedlings under and near fruiting *Virola* trees during the first few weeks after fruit fall.

GENERAL DISCUSSION

Mutually beneficial interactions between plants and animals may or may not be obligate, may or may not result from coevolution of particular plant and animal taxa, and may or may not have consequences for tropical forest conservation and management. If only because it is better known than others, the *Virola surinamensis* dispersal system does offer insights into general issues likely to be important in other relationships between plants and fruit-eating animals.

The Virola *Dispersal System*

The three foci of this investigation each have implications for other dispersal systems in the Old and New Worlds.

First, fruiting trees may depend upon, and perhaps be important for, a small proportion of the total frugivore fauna in a given tropical forest. Though it produces one of the most energy-rich arils known, *Virola surinamensis* consistently attracts only seven of 80 (9%) potential dispersal agents on Barro Colorado Island. Some birds, such as manakins (Pipridae) weighing 12-20 g, are simply too small to swallow the fruits. That size is not the key issue is clear from the fact that the much smaller seeded *Virola sebifera* attracts the same frugivores in the same forest (Howe 1981). Many mammals eat fruits, but the most abundant fruit-eating monkeys and bats in the Barro Colorado forest shun *Virola.* Whether this is due to inaccessibility or to chemical defenses against wasteful foragers is not known. Whatever the reasons that 90% of the available frugivores always or usually ignore *Virola* fruits, the plant and its small "gallery of connoisseurs" show a certain degree of specialization.

On closer examination, frugivore use of *Virola* is even more particular. On the average, half of each *Virola* crop drops underneath the fruiting trees and is killed by insects or mammals, and half is scattered through the forest, Over half of the seeds transported more than 15 or 20 m are taken by two large toucans or a guan, or by wasteful spider monkeys. Of these relatively regular dispersal agents, only one large toucan (*Ramphastos swainsonii*) both takes a large proportion of the fruits eaten by animals (35%), and habitually carries a large proportion of those that it eats (60%) more than 20 m from the trees. On Barro Colorado Island, observations of the feeding activity of frugivores suggest that *Virola surinamensis* is at least potentially dependent on this toucan species. Similar dependence on one or two dispersers has been inferred for other Central American trees (Howe 1977, 1980, 1981; Greenberg 1981), but the numerical evidence for *Virola surinamensis* is much more complete.

Secondly, *Virola* trees compete for dispersal agents. The proportion of fruits that are not disseminated by any animal varies annually from 35 to 60%, and in any given year the failure of different trees may range from 9 to 87%. Much of this variation is unexplained, especially during years of fruit superabundance. But in lean years as much as 60% of this variation can be explained by the mean ratio of edible aril to indigestible seed of individual trees, and by proximity of heavily fruiting neighbors (Howe 1983). Variation in individual dispersal occurs in other trees, such as *Casearia corymbosa* (Howe and Vande Kerckhove 1979), *Tetragastris panamensis*

(Howe 1980), and *Virola sebifera* (Howe 1981), but the components of variance remain unknown.

The influence of aril/seed ratio on dispersal is consistent with some theoretical expectations, but is anomalous for others. As expected, "seediness" counts. Foragers take more fruits from trees with a high benefit in edible pulp for the cost of carrying bulky seed ballast than they do from others (see Herrera 1981).

Unexpectedly, this pattern shows up in years or in portions of seasons in which *Virola* fruits are scarce. Theory predicts that animals favor the most "profitable" food (here with the highest aril/seed ratio), the more common it is (MacArthur 1972). The apparently anomalous result is probably due to the fact that fruit-eating birds face several contingencies which most insect-eating birds, such as the ones modelled by MacArthur, do not. Accessibility of superabundant fruits overrides inherent preferences in several small manakins and tanagers (Moermond and Denslow 1983, Levey *et al.* 1984), and probably accounts for the lack of apparent selectivity by *Virola* visitors when fruits are abundant. Birds must often travel hundreds of metres from nests, territories, or other food sources to feed in the rare "best" trees; it is not worth their while when *Virola* fruits are common. When fruits are scarce, these same birds rapidly deplete trees with the "best" aril/seed ratios, and then forage for other foods. This interpretation is consistent with the general view that birds compete for fruits only during times of scarcity (R. Foster 1982b, Fleming 1979). Explicit tests of such hypotheses are only now becoming possible, as foraging models become available which give realistic weight to competition for fruits and to long-distance foraging costs (Martin 1985).

Thirdly, some tropical trees are heavily dependent on seed transport for normal seedling recruitment. Disproportionate mortality from pathogen attack clearly makes seed dissemination by wind important for *Platypodium* recruitment (Augspurger 1983, Augspurger and Kelly 1984), and a variety of investigations of varying depth suggest the same for animal dispersed species (see Clark and Clark 1984). The *Virola* study is unique in demonstrating a 40 fold advantage to local dispersal by known seed vectors, and in sorting out the various sources of mortality. While mammals and weevils each account for half of *Virola* seeds and young seedlings killed shortly after fruitfall, only the insects have a decisive effect on the advantage to seed escape (see Janzen 1970, contra Connell 1971). In *Virola surinamensis,* the 99.96% mortality of seeds and seedlings directly under crowns of fruiting trees makes it very unlikely that the species could reproduce without dispersal agents.

Implications for Coevolution

Many or even most angiosperms produce fruits adapted for animal consumption, and many birds and mammals eat fruits and disseminate viable seeds. Do plants and particular dispersal agents "coevolve," or influence each other's evolution? In theory, coevolution of species pairs is possible even among non-symbiotic mutualists (Roughgarden 1983). Both pollination and seed dispersal of some mistletoes (Loranthaceae) by flowerpeckers (Dicaidae) may reflect coevolution of species pairs (Docters van Leeuwen 1954, Davidar 1978, 1983). A legitimate question is whether conditions of coevolution are met for *Virola surinamensis* and the animals that eat its fruits, or for similar dispersal systems. An alternative is that plants evolve means of attracting an array of animals, which may or may not be closely related, that provide more or less similar services (Janzen 1980, Herrera 1982, Howe 1984a). Similarly, fruit-eating animals may evolve general adaptations for finding and processing fruits, without regard to species of food plants (Moermond and Denslow 1985; Wheelwright 1985). Specialization might only limit the range of dispersal agents used by plants or the range of food items preferred by animals.

The *Virola* system has some, but not all, preconditions for coevolution of species pairs. The plant appears to be entirely dependent on animals for seedling recruitment; on Barro Colorado Island one *Ramphastos* toucan is a far more reliable dispersal agent than others. The degree of dependence of the toucan on *Virola* is not well known, but heavy use of these trees over many years suggest the probability of a close, if not obligate, relationship. Furthermore, the distaste of many mammals of *Virola* arils, and the distaste of even consistent visitors like spider monkeys for the arils of some *Virola* trees, suggests that the plant has defended itself against some wasteful visitors (see Howe 1980, 1983). Based on studies on Barro Colorado Island alone, coevolution between nutmegs and toucans might seem reasonable. Several points argue against this interpretation, however.

First, unrelated birds perform similar dispersal functions for *Virola surinamensis*; differences in "reliability" probably reflect different abundances more than different adaptive potentials. Guans (Cracidae) are not at all closely allied with toucans (Ramphastidae), yet they disperse these seeds as well as the much more common toucans. Similar potential among distantly related dispersal agents has also been noted for other bird-dispersed trees (e.g. Howe and Vande Kerckhove 1979, Wheelwright and Orians 1982), as well as for one monkey-dispersed tree (Howe 1980). The close dependence of *Virola surinamensis* and *Ramphastos swainsonii* is probably a local relationship, which may or may not be as strong elsewhere.

Second, geographical ranges do not closely overlap. *Ramphastos swainsonii* occurs north of the *Virola surinamensis* range, and the tree occurs well south of the toucan range. Congeners of both do overlap throughout Central and South America, and some scattered observations show that toucans eat nutmegs of other species in quantity (Bourne 1977; Howe 1977, 1981). It may be that these food preferences represent a long common history between New World nutmegs and toucans, although the plants are dispersed by other animals, and the toucans certainly eat fruits of many other plants.

Third, ecological variation makes coevolution of species pairs highly unlikely (Howe 1984a). Normal variation in *Virola* spatial distributions, densities, size and fecundity distributions, and weather all affect the fruit resources available to toucans or other animals in any given time or place. Similar factors, affecting other fruit-bearing tree species, as well as the relative abundances of other fruit-eating animals, quite likely influence toucan loyalty to nutmegs. Such variation will clearly alter selective intensity of birds on plants, and plants on birds, over time and space.

Fourth, assymmetries in mutualisms preclude coevolution. Asymmetries in dependence appear to be common in both pollination (Schemske 1983) and seed dispersal (Howe 1984a). A rare plant with low fecundity may require common birds with generalized food habits. More commonly, a plant provides a critical resource for animals which do not disperse its seeds. To the degree that a plant or animal relies on another species less than the other species relies on it, evolutionary rates in the two species will differ.

Finally, there is as yet little evidence that plant and particular bird taxa have coexisted for long. Snow (1981) comments that many African tree taxa existed long before their contemporary dispersal agents evolved. Herrera (1985) finds that, in general, angiosperm shrubs and trees average 27 and 38 million years in the fossil record, while mammals and birds average 0.5-4.0 and 0.5 million years, respectively. Given that plant fossils are more common than those of small vertebrates, and that the taxonomic status of plant and animal fossils may be only roughly comparable, it still seems likely that evolution modifies fruit structure far more slowly than it modifies animals that eat fruits. Animals appear to adjust, both behaviorally in a local community and evolutionarily over millenia, to whatever fruit resources are at hand. Plants that find themselves without adequate dispersal agents for any considerable length of time probably become locally extinct (Howe 1985).

Implications for Conservation

Networks of ecological interdependence pose hazards for forest management. A chance extinction or omission of a keystone tree or frugivore species from a forest reserve could in theory precipitate a chain reaction of local extinctions, leading to abrupt changes in overall species composition (Howe 1977, 1984b; Gilbert 1980). In this context a “keystone” species is one which is critical for the survival of several other species in the community. The potential for such losses always exists because isolated reserves always lose species from random extinction (MacArthur 1972). The potential for interconnected extinctions is especially high in diverse seasonal tropical forests in which most species are rare (see Hubbell and Foster 1982), and which often experience wide variations in fruiting phenologies (see Foster 1982a, 1982b).

At present, no one knows whether keystone mutualists are common in nature because few dispersal systems are known in enough detail to allow a strong inference. Some do fit the keystone mould. For instance, an uncommon *Casearia* in one Costa Rican reserve helps maintain its dispersal agent, *Tityra semifasciata*, and 21 other species of fruit-eating birds through an annual scarcity of fruit production in December (Howe 1977, see Frankie *et al.* 1974). Failure of this tree would undoubtedly decimate several bird species which are dispersal agents of other plants at other times of the year. On Barro Colorado Island, the small-seeded *Virola sebifera* supports at least three obligate frugivores, including two critical to *Virola surinamensis*, through seasonal scarcity in November and December (Howe 1981). But this plant is common on the island. It is a “keystone” ecologically, but is both abundant enough and consistent enough in its fruiting phenology that its failure is unlikely. *Virola surinamensis* requires seed dispersal for its reproduction, and attracts several of the same birds that use its small congener. However, *V. surinamensis* bears fruits in June, July, and August, when many other trees are also productive (Foster 1982a). Chance failure of this species would be unlikely, and would in any case not affect frugivores that could switch to other fruits during an emergency.

In short, keystone or pivotal species may be critical features of tropical forests (Howe 1977, Gilbert 1980). Their chance extinction or omission from natural reserves is most likely in refuges of small area, highly diverse biota and seasonal climate (Howe 1984b). The keystone concept is only partially relevant to

Virola surinamensis. The tree would undoubtedly vanish if its dispersal agents disappeared, but at least some of its dispersal agents might be capable of switching to other foods if the tree failed or became locally extinct. But permanent disappearance of this plant from Barro Colorado Island probably would reduce populations of toucans and guans, with as yet unknown ramifications on other animal-dispersed plants of the forest.

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PHYTOCHOROLOGY OF KODAGU (COORG) DISTRICT, KARNATAKA

J. P. PASCAL[1] AND V. M. MEHER-HOMJI[2]

(*With three text-figures*)

This study on phytochorology attempts to explain the vegetation patterns in relation to climatic conditions. Three main types distinguished are (1) potential evergreen forests, sub-divided into three types according to elevation, (2) potential moist deciduous and (3) dry deciduous forests.

The potential evergreen forests enjoy a rainfall of over 2000 mm, a tropical régime with a single peak of rains in July and 4 dry months; it is the elevation and the factor most closely linked to it—the temperature—which distinguish the three types: (a) *Dipterocarpus-Kingiodendron-Humboldtia* upto 750 m altitude, (b) *Mesua-Palaquium* from 750 to 1400 m and (c) *Schefflera-Gordonia-Meliosma* above 1400 m.

The disturbed forests, woodland, savanna-woodland and coffee plantations within the potential evergreen forest belt occur within the range of 2000 to 5000 mm rainfall; below this lower limit of rainfall dominate the moist (*Lagerstroemia-Tectona-Dillenia*) and dry deciduous (*Anogeissus-Tectona-Terminalia*) forests; they occur below 900 m, the former with a rainfall of 1400-2000 mm and a dry season of 4-5 months, the latter within 900-1400 mm belt with 5 months dry.

INTRODUCTION

Chronology is the term used to describe the sequence of events in time. Chorology is the scientific study of the geographical extent or distribution in space. It also means causal study of the distribution of organisms. The term was used in 1883 by von Richthofen to mean the explanatory distribution of areas (Dudley Stamp 1966). Phytochorology thus refers to the spatial distribution of vegetation depicted on a map.

Location.

The Kodagu (Coorg) district forms the south-west part of Karnataka State. It lies between latitude 11°56′-12°52′ North and longitude 75°22′-76°11′ East, bounded on the north by the Hassan district, on the west by South Kanara, on the east by Mysore district and in the south by the Cannanore district of Kerala.

Coorg is the anglicized form of the word Kodagu, which according to one version is derived from Kodimalenad meaning dense forest-land on steep hills; the other view is that Kodagu means the country of millions of hills as the district has a mountainous configuration. The main range of the Western Ghats extends to about 100 km from the Brahmagiris in the south to the Subramanya in the north-west. Several long and elevated ridges run west to east from this portion of the Western Ghats (Anonymous 1965).

The southern section of the Ghats, the Brahmagiris (average elevation 1360 m) forms the southern boundary with the Wynad plateau of Kerala. Incidentally, there is also another Brahmagiri peak near Bhagmandala which is the source of the Kaveri. The highest peak of the district, Tadiandamol, is at 1734 m. Other notable peaks are in the Pushpagiri hill at 1700 m and at Kotebeta (1600 m) which is one of the ridges that branches off from the Subramanya range.

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Madikeri (Mercara) plateau at an average elevation of about 1050 m extends northwards as far as Somwarpet, a distance of 30 km but on the east slopes down to the Kaveri.

This hilly district may broadly be divided into two, — the uplands in the west and the lower land in the east.

Previous studies.

Among the studies on the evergreen forests of the Western Ghats in Karnataka, the most complete synthesis is that of Pascal (1984). Earlier, there have been some good attempts notably by Kadambi (1939). Rai (1981) has given a good account of the production aspect. As to the vegetation of Kodagu district itself, mention may be made of the investigations of Arora (1960, 1964a, b). Lakshmana and Subramanyam (1976, 1977) have provided information on the grassy patches of the district.

Climate.

The climate has been summarised in Fig. 1 after Pascal (1982). Three classes of temperature have been recognised on the basis of the mean temperature of the coldest month (t):

(1) t > 23°C
(2) t between 16°C and 23°C
(3) t between 13.5°-16°C, which class corresponds to the higher elevations of the Ghats.

From point of view of annual average rainfall, five classes have been distinguished ranging from over 5000 mm per annum to 900-1200 mm.

The combination of the above temperature and rainfall ranges result in 8 climatic classes as given in the legend of Fig. 1. On the basis of length of dry season, two categories have been formed:

— 4 months dry*
— 5 months dry

The five dry months category corresponds to the two lower rainfall classes (1200-1500 mm and 900-1200 mm). The map in Fig. 1 is accompanied by climate diagrams depicting the rainfall curves. Meher-Homji (1979) has analysed the inter-annual variability of the climate of Madikeri (Mercara).

The district may clearly be divided into two vertical halves, a wider western elevated portion with rainfall of over 1500 mm and dry season of 4 months and a narrower lower eastern fringe with rainfall ranging from 900 to 1500 mm and a longer dry period of 5 months.

To these distinct climatic-physiographic divisions correspond vegetational differences.

Vegetation.

The western rainy portion is potentially a zone of evergreen forests whereas the drier eastern fringe is a zone of deciduous forests.

Evergreen forests.

Earlier workers recognised essentially one main evergreen type, as for example *Mesua-Calophyllum-Dipterocarpus* type of Arora (1960) with mention of "mixed communities with three or more codominant species" and "mixed associations of evergreen species".

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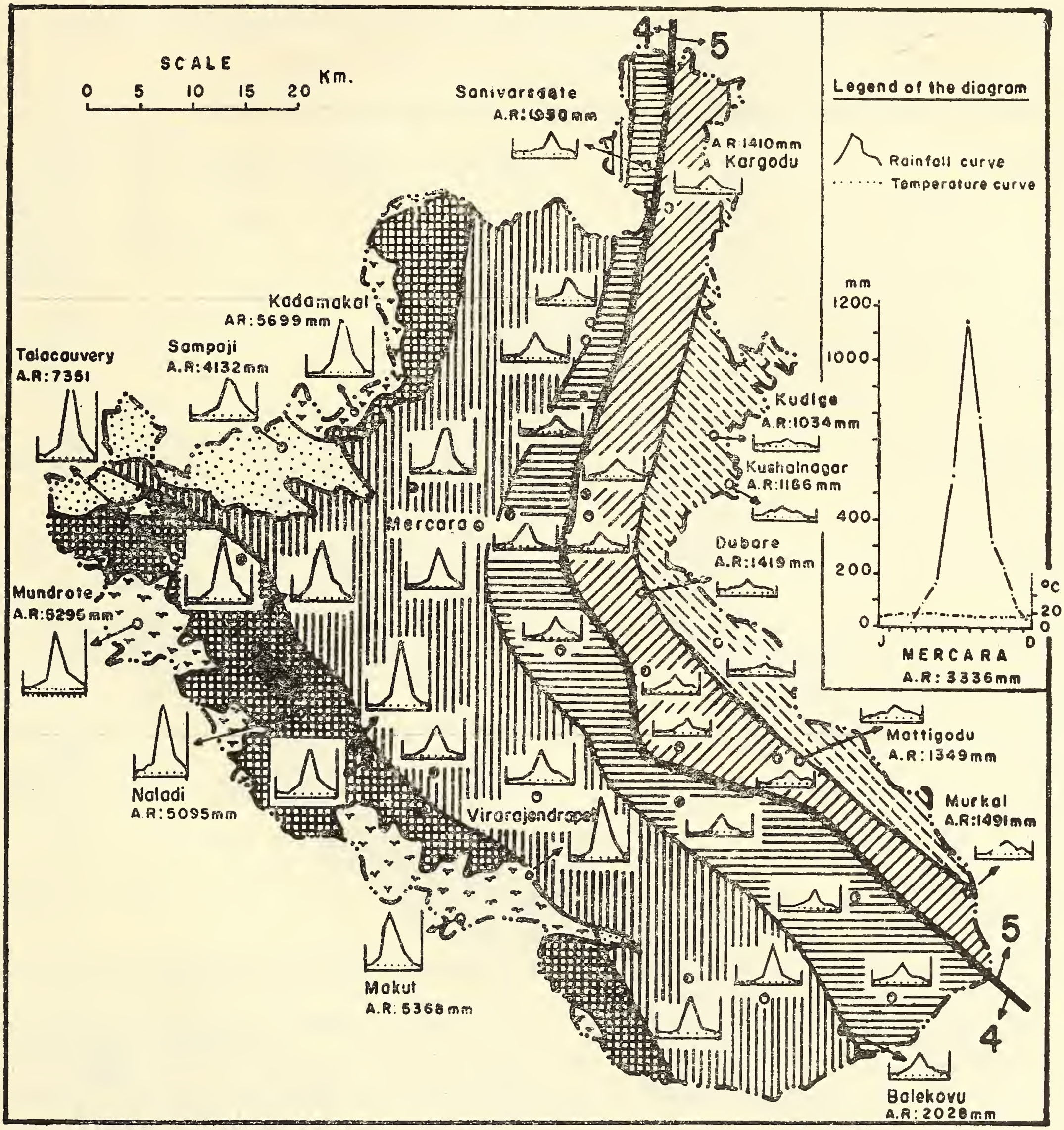
* A month is defined as dry when its mean monthly rainfall in mm is less than twice its mean monthly temperature in °C (Bagnouls and Gaussen 1953).


SCALE
0 5 10 15 20 Km.
4
5
Sanivarsante
A.R: 1650 mm
A.R: 1410 mm
Kargodu
Legend of the diagram
Rainfall curve
Temperature curve
Kodamakal
AR: 5699 mm
Sampaji
A.R: 4132 mm
Talacauvery
A.R: 7351
Kudige
A.R: 1034 mm
Kushalnagar
A.R: 1186 mm
Mercara
Dubare
A.R: 1419 mm
Mundrote
A.R: 6295 mm
mm
1200
1000
400
200
0
°C
20
0
J
D
MERCARA
A.R: 3336 mm
Mattigodu
A.R: 1349 mm
Murkal
A.R: 1491 mm
Naladi
A.R: 5095 mm
Virarajendrapet
Makut
A.R: 5368 mm
5
4
Balekovu
A.R: 2028 mm

Temperature(°C) / Rainfall(mm)	13°5 < t < 16°	16° < t < 23°	t > 23°
P > 5000	■	▦	▿
2000 < P < 5000		▥	⁘
1500 < P < 2000		▤	
1200 < P < 1500		▨	
900 < P < 1200		▧	

P = Annual average rainfall (mm)

t = Mean temperature of the coldest month (°C)

4 = No of dry months

Fig. 1. Bioclimatic map :- Kodagu district (After J. P. Pascal 1982).

TABLE 1

BIOCLIMATIC CHARACTERISTICS OF THE FOREST TYPES

Type	Altitude (m)	Rainfall amount (mm)	Rainfall regime	No. of dry months	Temperature (°C)	
					Mean of the coldest month	Mean of minimum of the coldest month
I. Evergreen						
(1) *Dipterocarpus-Kingiodendron-Humboldtia*	Low elevation upto 750 m	>2000 (even exceeding 5000)	Tropical with a single peak in July	4	>20	⩾ 14
(2) *Mesua-Palaquium*	Medium elevation 750-1400 m	„	„	4	16–23	< 15
(3) *Schefflera-Gordonia-Meliosma*	High elevation > 1400 m	„	„	4	13–16	9–13
(4) Disturbed forests, woodland to savanna-woodland, coffee plantations within the potential evergreen forest belt	Low to high	2000–5000	„	4	Within the above range	
II. Deciduous						
(1) Moist deciduous *Lagerstroemia-Tectona-Dillenia*	Low elevation < 900 m	1400–2000	Tropical with a secondary peak in October	4–5	>20	13–20
(2) Dry deciduous *Anogeissus-Tectona-Terminalia*	„	900–1400	„	5	>20	13–20

In the present work, three distinct evergreen forest types have been distinguished on floristic basis, linked with altitude and climatic factors (Table 1; Fig. 2).

(1) *Dipterocarpus indicus* — *Kingiodendron pinnatum* — *Humboldtia brunonis* type occurs at lower elevation, under 750 m with rainfall of over 2000 mm and dry season of 4 months. The mean of the coldest month is over 20°C and the mean of the minimum of the coldest month over 14°C.

(2) *Mesua ferrea* — *Palaquium ellipticum* type prevails at medium elevation between 750-1400 m. The rainfall amount and distribution remain the same as in the preceding type but the mean temperature of the coldest month is lower: 16°-23°C, and mean of minimum of the coldest month is under 15°C.

The Dipterocarpaceae and the Ebenaceae which dominate at low altitude have a minor role to play. The Clusiaceae (*Mesua, Calophyllum, Garcinia*), the Sapotaceae (*Pala-*

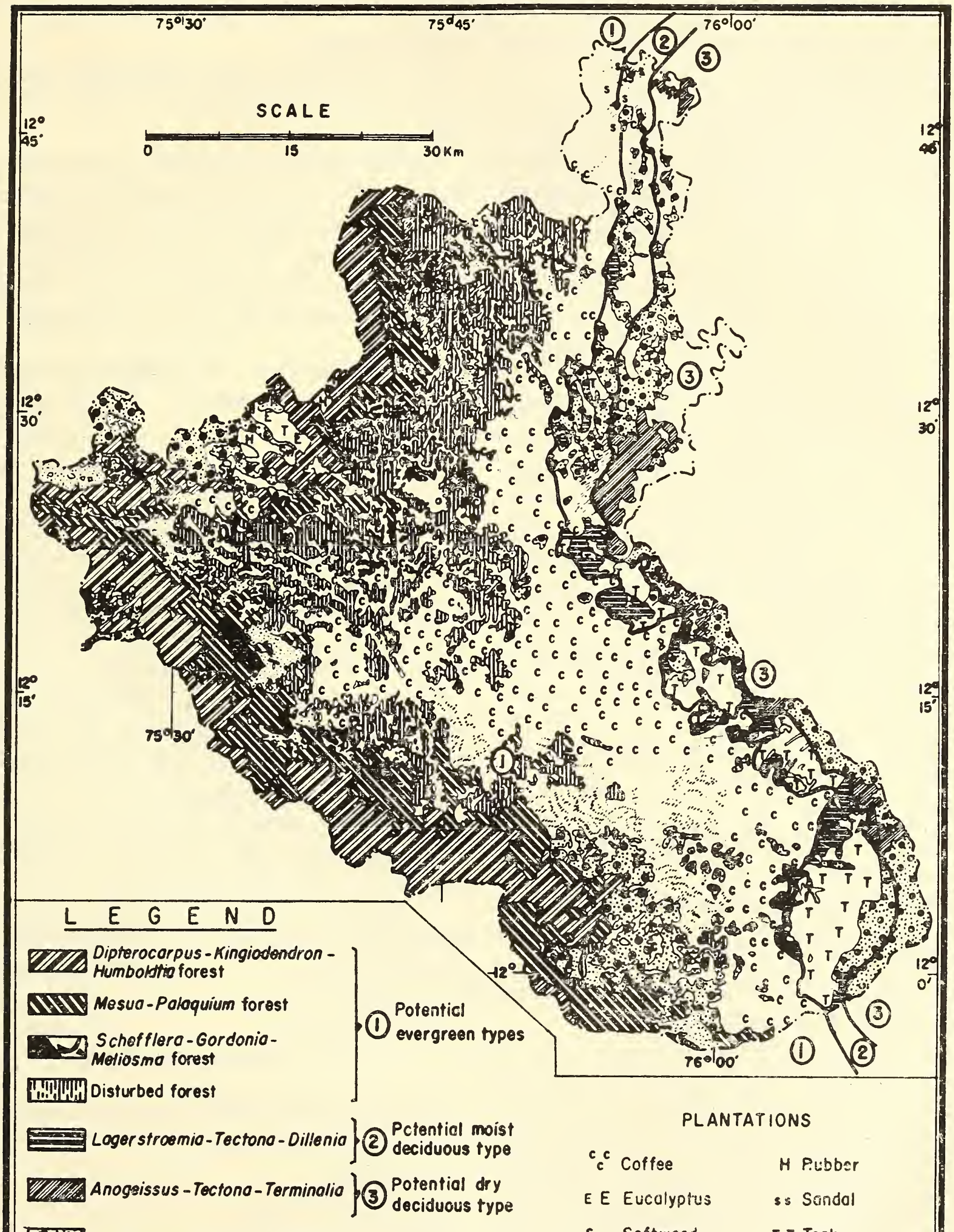

75°30'
75°45'
76°00'
SCALE
0
15
30 Km
12° 45'
12° 30'
12° 15'
12° 0'
12°
① ② ③
LEGEND
Dipterocarpus - Kingiodendron - Humboldtia forest
Mesua - Palaquium forest
Schefflera - Gordonia - Meliosma forest
Disturbed forest
① Potential evergreen types
Lagerstroemia - Tectona - Dillenia
② Potential moist deciduous type
Anogeissus - Tectona - Terminalia
③ Potential dry deciduous type
Woodland to savanna-woodland
Thicket
Tree savanna to scattered shrubs
PLANTATIONS
c c Coffee
H Rubber
E E Eucalyptus
s s Sandal
Sw Softwood
T T Teak
Limits of Potential types

Fig. 2. Vegetation map of Kodagu (Coorg) District.
(After Pascal, Shyam Sunder & Meher-Homji 1982)

quium), the Meliaceae (*Aglaia*) and the Euphorbiaceae (*Agrostistachys, Mallotus, Drypetes*) gain importance.

(3) A montane type develops at higher elevation of over 1400 m in the Western Ghats. This type is termed *Schefflera* spp. - *Gordonia obtusa-Meliosma.* Mean of the coldest month is 13°-16°C and that of minimum of the coldest month 9° to 13°C.

The nomenclature of the type *Schefflera-Gordonia-Meliosma* is that of Gaussen *et al.* (1965). However, it does not bring out the essential floristic features: the dominance of Lauraceae (*Litsea, Cinnamomum, Alseodaphne, Actinodaphne, Neolitsea*), particularly conspicuous from 1400 to 1600 m in the W. Ghats and of Myrtaceae (*Eugenia, Syzygium, Rhodomyrtus*). The Araliaceae is also well represented with five species of *Schefflera* among which some begin their existence as epiphytes like certain species of *Ficus.*

Among other important families are the
Anacardiaceae (*Holigarna, Mangifera, Meliosma*),
Celastraceae (3 species of *Elaeocarpus*),
Euphorbiaceae (*Agrostistachys, Glochidion, Mallotus* ...),
Flacourtiaceae (*Casearia, Flacourtia, Hydnocarpus, Scolopia*),
Myrsinaceae (*Ixora, Lasianthus, Psychotria*...),
Staphyleaceae (*Turpinia*),
Symplocaceae (*Symplocos*).

The detailed floristic composition of the three evergreen types is given in Table 2.

Disturbed Forests in Evergreen types.

They appear over the entire area of the evergreen forests when exploitation is very intensive. Considerable removal of commercial trees and numerous and extensive openings have brought about a profound change in the climatic conditions and in the populations of certain species. It is this state of structural and floristic disturbance that characterizes the *disturbed forests.*

The emergents have disappeared and the upper storey is relatively low and discontinuous.

The understorey is invaded by young subjects on account of openings made for exploitation.

In the upper storey are found evergreen light tolerant species with a large ecological amplitude, which are common to all disturbed forests. Among these may be mentioned.

Alstonia scholaris
Artocarpus heterophyllus
A. hirsutus
Canarium strictum
Carallia brachiata
Cinnamomum spp.
Dimocarpus longan
Dysoxylum malabaricum
Elaeocarpus serratus
Holigarna arnottiana
H. grahamii
Hopea ponga
Knema attenuata
Mangifera indica
Myristica dactyloides
Persea macrantha
Polyalthia fragrans
Syzygium cumini

Woodland to Savanna-woodland.

These are open forests. There is a continuous cover of tall grasses in the savanna-woodland, in absence of which the formation is referred to as woodland.

In the *tree savanna* are seen twisted low-branched fire-resistant individuals of less than 8 m height like

Wendlandia notoniana
Ziziphus rugosa
Z. oenoplia
Careya arborea
Emblica officinalis
Gardenia turgida
G. gummifera
Glochidion sp.
Phoenix humilis (dwarf palm)

A few low deciduous trees are also encountered:
Terminalia paniculata,
T. chebula,
Buchanania lanzan,
Bridelia sp.,
Butea monosperma.

TABLE 2

FLORISTIC LISTS OF EVERGREEN FORESTS

	Forest types		
	Dipterocarpus-Kingiodendron-Humboldtia 1	*Mesua-Palaquium* 2	*Schefflera-Gordonia-Meliosma* 3
UPPER STOREY			
Acrocarpus fraxinifolius Wt.	+		
Aglaia roxburghiana Hiern	+		
Antiaris toxicaria Lesch.	+		
Bombax ceiba L.	+		
Calophyllum apetalum Willd.	+		
C. polyanthum Wall. ex Choisy	+		
Dipterocarpus indicus Bedd.	+		
Dysoxylum malabaricum Bedd.	+		
Fahrenheitia zeylanica (Thw.) Airy Shaw	+		
Holigarna grahamii (Wt.) Kurz	+		
Hopea parviflora Bedd.	+		
H. ponga (Dennst.) Mabberley	+		
Kingiodendron pinnatum (DC.) Harms.	+		
Lophopetalum wightianum Arn.	+		
Myristica malabarica Lam.	+		
Ormosia travancorica Bedd.	+		
Polyalthia fragrans (Dalz.) Bedd.	+		
Pterygota alata R. Br.	+		
Terminalia bellerica (Gaertn.) Roxb.	+		
Bischofia javanica Bl.		+	
Actinodaphne malabarica Balak.			+
Alseodaphne semecarpifolia Nees			+
Bhesa indica (Bedd.) Ding Hou			+
Cinnamomum wightii Meissn.			+
Cryptocarya lawsoni Gamble			+
C. neilgherrensis Meissn.			+
Garcinia pictorius (Roxb.) D'Arey			+
Litsea stocksii Hk. f.			+
Meliosma pinnata (Roxb.) Walp. ssp. *arnottiana* (Walp.) Bers.			+
M. simplicifolia (Roxb.) Walp.			+
Michelia champaca L.			+
Schefflera capitata Harms.			+
S. micrantha Gamble			+
S. racemosa Harms.			+
Syzygium caryophyllatum (L.) Alst.			+
Turpinia cochinchinensis (Lour.) Mori			+

TABLE 2 (contd.)

T. malabarica Gamble			+
Alstonia scholaris (L.) R. Br.	+	+	
Artocarpus heterophyllus Lam.	+	+	
A. hirsutus Lam.	+	+	
Mastixia arborea (Wt.) Bedd.	+	+	
Mesua ferrea L.	+	+	
Mimusops elengi L.	+	+	
Palaquium ellipticum Engl.	+	+	
Strombosia ceylanica Gardn.	+	+	
Syzygium gardneri Thw.	+	+	
Vateria indica L.	+	+	
Beilschmiedia wightii Benth.	+		+
Elaeocarpus serratus L.		+	+
Lagerstroemia microcarpa Wt.		+	+
Syzygium cumini (L.) Skeels		+	+
Canarium strictum Roxb.	+	+	+
Dimocarpus longan Lour.	+	+	+
Elaeocarpus tuberculatus Roxb.	+	+	+
Holigarna arnottiana J. Hk.	+	+	+
Mangifera indica L.	+	+	+
Persea macrantha Kost.	+	+	+
Toona ciliata Roem.	+	+	+
UPPER & MIDDLE STOREY			
Drypetes elata (Bedd.) Pax & Hoffm.	+		
Hydnocarpus laurifolia (Dennst.) Sleumer	+		
Symphyllia mallotiformis Muell.	+		
Vitex altissima L.f.	+		
Drypetes oblongifolia (Bedd.) Airy Shaw		+	
Agrostistachys meeboldii Pax & Hoffm.			+
Cinnamomum sulphuratum Nees			+
Gordonia obtusa W. & A.			+
Litsea bourdillonii Gamble			+
L. floribunda Gamble			+
Knema attenuata (J. Hk. & Th.) Warb.	+	+	
Cinnamomum verum Presl.	+		+
Dillenia pentagyna Roxb.	+		+
Zanthoxylon rhetsa (Roxb.) DC.	+		+
Syzygium hemisphericum (Walp.) Alst.		+	+
Vernonia arborea Ham.		+	+
Caryota urens L.	+	+	+
Garcinia gummi-gutta (L.) Robson	+	+	+
Macaranga peltata (Roxb.) Muell.	+	+	+
Myristica dactyloides Gaertn.	+	+	+
Olea dioica Roxb.	+	+	+
MIDDLE STOREY			
Aphanamixis polystachya (Wall.) Parker	+		
Artocarpus gomezianus Wall.	+		
Cryptocarya bourdilloni Gamble	+		

TABLE 2 (contd.)

Diospyros crumenata Thw.	+		
D. pruriens Dalz.	+		
D. stricta Roxb.	+		
Garcinia talbotii Raizada ex Sant.	+		
Madhuca neriifolia (Moon) Lam.	+		
Pajanelia longifolia (Willd.) Schum.	+		
Trewia nudiflora L.	+		
Walsura trifolia (A. Juss.) Harms.	+		
Agrostistachys indica Dalz.			+
Apodytes benthamiana Wt.			+
Apollonias arnottii Nees			+
Daphniphyllum neilgherrense Ros.			+
Eugenia mooniana Wt.			+
Euonymus crenulatus Wall.			+
E. dichotomus Heyne			+
Isonandra montana Gamble			+
Litsea oleoides Hk. f.			+
Mallotus tetracoccus (Roxb.) Kurz			+
Neolitsea zeylanica Merr.			+
Phoebe wightii Meissn.			+
Symplocos cochinchinensis (Lour.) Moore ssp. *laurina* (Retz.) Noot			+
S. macrophylla Wall. ex DC.			+
Syzygium arnottianum Walp.			+
S. rubicundum W. & A.			+
Carallia brachiata (Lour.) Merr.	+	+	
Garcinia indica Choisy	+	+	
G. morella Desr.	+	+	
G. pictorius (Roxb.) D'Arey	+	+	
Otonephelium stipulaceum (Bedd.) Radlk.	+	+	
Fagraea ceilanica Thunb.		+	+
MIDDLE & UNDER STOREY			
Aglaia anamallayana (Bedd.) Kost.	+		
Aporosa lindleyana (Wt.) Baill.	+		
Baccaurea courtallensis Muell.	+		
Polyalthia cerasoides (Roxb.) Bedd.	+		
Elaeocarpus tectorius (Lour.) Poir.		+	
Casearia coriacea Thw.			+
C. rubescens Dalz.			+
Glochidion ellipticum Wt.			+
G. fagifolium Hk. f.			+
G. neilgherrense Wt.			+
G. zeylanicum A. Juss.			+
Gomphandra coriacea Wt.			+
Ligustrum gamblei Ramam.			+
Rhodomyrtus tomentosa Wt.			+
Hydnocarpus alpina Wt.	+		+
Elaeocarpus munroii (Wt.) Mast.		+	+

TABLE 2 (contd.)

Scolopia crenata Clos.		+	+
Symplocos racemosa Roxb.		+	+
Tricalysia apiocarpa Gamble		+	+
Viburnum punctatum Ham. ex Don		+	+
Callicarpa tomentosa (L.) Murr.	+	+	+
Trichilia connaroides W. & A.	+	+	+
UNDER STOREY			
Arenga wightii Grif.	+		
Euonymus indicus Wall.	+		
Harpullia arborea (Blanco) Radlk.	+		
Isonandra lanceolata Wt.	+		
Leptonychia moacurroides Bedd.	+		
Memecylon umbellatum Burm.	+		
Microtropis stocksii Gamble	+		
Neonauclea purpurea (Roxb.) Merr.	+		
Nothopegia beddomei Gamble	+		
Beddomea simplicifolia Bedd.		+	
Apama siliquosa Lam.			+
Ardisia rhomboidea Wt.			+
A. solanacea Roxb.			+
A. sonchifolia Mez.			+
Canthium neilgherrense Wt.			+
Dimorphocalyx lawianus Hk. f.			+
Ixora nigricans W. & A.			+
I. notoniana Wall.			+
Lasianthus rostratus Wt.			+
Memecylon gracile Bedd.			+
M. malabaricum (Cl.) Cogn.			+
Pittosporum neelgherrense W.&A.			+
Psychotria elongata Hk. f.			+
P. globicephala Gamble			+
P. truncata Wall.			+
Sauropus androgynus Merr.			+
Tarenna asiatica (L.) Schum.			+
Wendlandia thyrsoidea (R. & S.) Steud.			+
Humboldtia brunonis Wall.	+	+	
Pinanga dicksonii (Roxb.) Scheff.	+	+	
Syzygium laetum (Haw.) Gandhi	+	+	
Flacourtia montana Grah.	+		+
Acronychia pedunculata (L.) Miq.		+	+
Archidendron monadelphum (Roxb.) Niel.	+	+	+
Euodia lunu-ankenda (Gaertn.) Merr.	+	+	+
Mallotus philippensis (Lam.) Muell.	+	+	+
UNDER STOREY & UNDERGROWTH			
Blachia umbellata Baill.	+		
Gomphandra tetrandra (Wall.) Sleumer	+		

TABLE 2 (contd.)

Mollotus beddomei J. Hk.	+		
Memecylon angustifolium Wt.	+		
Canthium dicoccum (Gaertn.) T. & B.		+	
Goniothalamus cardiopetalus (Dalz.) J. Hk.		+	
Meiogyne ramarowii (Dunn.) Gandhi	+	+	
Antidesma menasu Miq. ex Tul.		+	+
Leea indica (Burm.) Merr.	+	+	+
UNDERGROWTH			
Atalantia wightii Tanaka	+		
Croton malabaricus Bedd.	+		
Ixora nigricans W. & A.	+		
Ochlandra travancorica Gamble	+		
Psychotria nigra (Gaertn.) Alst.	+		
Eurya japonica Thunb.		+	
Lasianthus acuminatus Wt.		+	
Maesa indica (Roxb.) DC.		+	
Psychotria dalzellii J. Hk.		+	
Apama siliquosa Lam.	+	+	
Debregeasia longifolia (Burm.) Wedd.	+	+	
Dendrocnide sinuata (Bl.) Chew.	+	+	
Ixora elongata Heyne	+	+	
Pandanus thwaitesii Mart.	+	+	
HERBS			
Elettaria cardamomum (L.) Maton	+		
Hedychium coronarium Koenig	+		
Lepianthes umbellata (L.) Raf.	+		
Schumannianthus virgatus (Roxb.) Rolfe	+		
Aeschynanthus perrottetii A. DC.		+	
Elatostema cuneatum Wt.		+	
Arisaema leschenaultii Bl.			+
Elatostema lineolatum Wt.			+
Hedyotis stylosa Br.			+
Sopubia delphinifolia (L.) Don			+
LIANAS			
Asparagus racemosus Willd.	+		
Bauhinia phoenicea W. & A.	+		
Canthium angustifolium Roxb.	+		
Combretum latifolium Bl.	+		
Coscinium fenestratum Colebr.	+		
Entada pursaetha DC.	+		
Calamus thwaitesii Becc. ex Becc. & J. Hk.		+	
Erythropalum populifolium (Arn.) Mast.		+	
Ventilago madraspatana Gaertn.		+	
Calamus huegelianus Mart.			+
Celastrus paniculata Willd.			+
Clematis gouriana Roxb.			+

TABLE 2 (contd.)

Elaeagnus kologa Schl.			+
Schefflera wallichiana Harms.			+
Scutia myrtina (Burm.) Kurz			+
Ancistrocladus heyneanus Grah.	+	+	
Gnetum ula Brong.	+	+	
Piper nigrum L.	+	+	
Smilax zeylanica L.	+	+	
Schefflera venulosa Harms.		+	+
Toddalia asiatica (L.) Lam.		+	+

The grass stratum is composed of species of *Andropogon, Arundinella, Chrysopogon, Cymbopogon, Heteropogon, Pollinia* and *Themeda.*

Deciduous Forests.

The deciduous forests occur under an elevation of 900 m and rainfall of less than 2000 mm. Another point of difference compared to the evergreen forests is whereas in the former the rainfall régime is tropical with a single peak in July, the areas under deciduous forests also exhibit a secondary peak in October besides the main July peak (Table 1).

Along the west-east increasing gradient of dryness, the deciduous forests are divided into two types: the moist deciduous *Lagerstroemia microcarpa-Tectona grandis-Dillenia pentagyna* type with rainfall of 1400-2000 mm and dryness of 4 to 5 months and the dry deciduous *Anogeissus latifolia-Tectona grandis-Terminalia alata* type (rainfall of 900-1400 mm and 5 months dry).

The following species of the moist deciduous forest tend to disappear in the dry deciduous type as they cannot tolerate lower rainfall prevailing in the zone of the dry deciduous forest.

Dillenia pentagyna
Lagerstroemia microcarpa
Alstonia scholaris
Vitex altissima
Anthocephalus cadamba
Mallotus philippensis
Callicarpa tomentosa
Clerodendrum viscosum
Bambusa arundinacea.

On the other hand, some species like *Anogeissus latifolia* become more frequent in the dry deciduous forest.

Thickets, tree savanna to scattered shrubs constitute different stages of degradation of moist and dry deciduous forests. Savanna physiognomy with tall grasses forming the ground-cover is the result when fire is a frequent phenomenon passing through the forest floor. The fire stimulates the growth of grasses. In a tree savanna, there are a few trees left amidst the grasses.

The other mode of degradation of the forest is through overgrazing and overbrowsing. All the palatable species including grasses have been eliminated. Due to dearth of inflammable material, fire can no longer pass through the formation. Thorny and spiny shrubs and stragglers predominate forming a thicket. The thicket may be reduced to a stage of scattered shrubs because of intensive anthropic activities.

Fig. 3 depicts a West-North-West—East-South-East oriented climate-vegetation transect

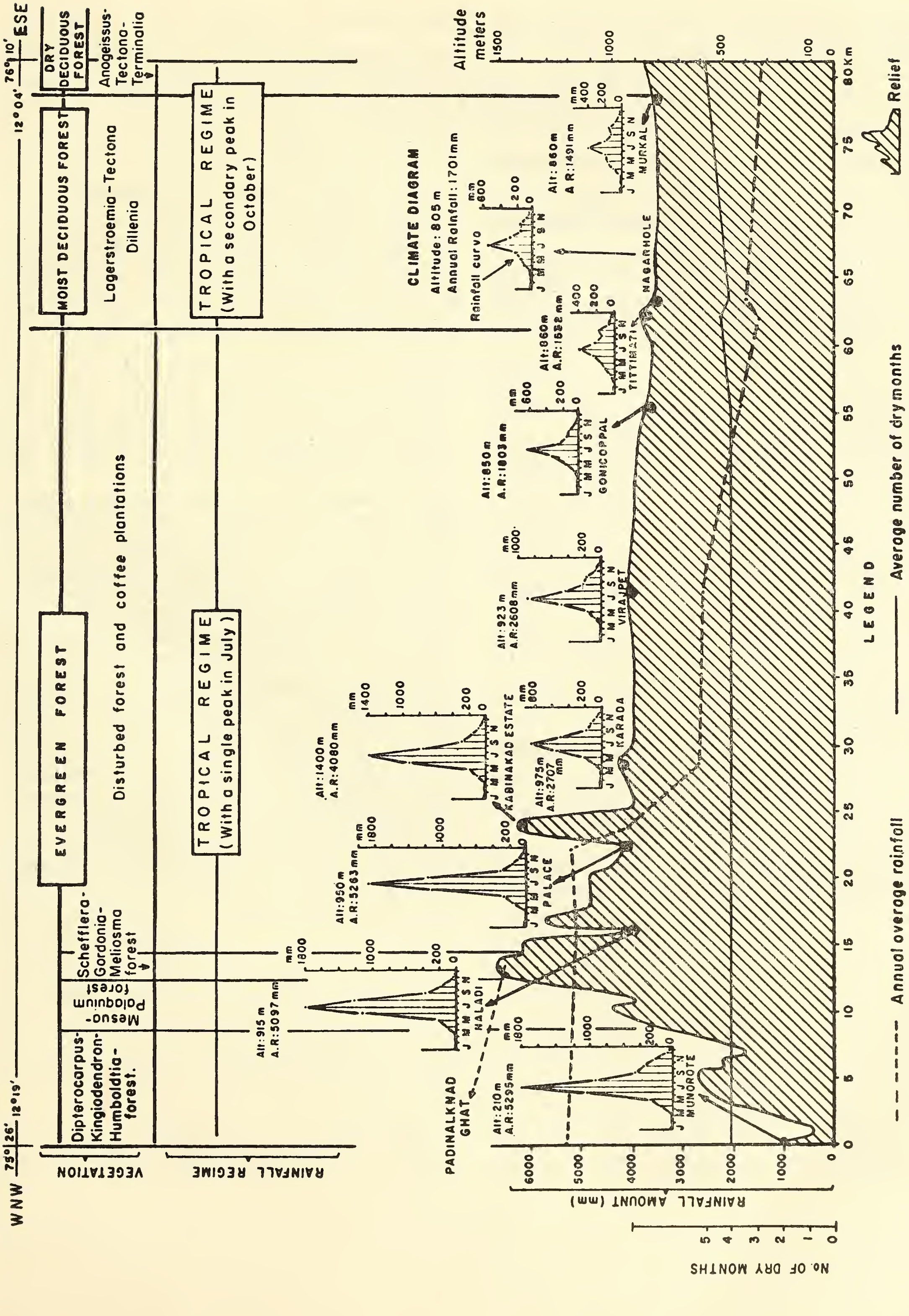

WNW
75°26'
12°19'
12°04'
76°10'
ESE
VEGETATION
Dipterocarpus-Kingiodendron-Humboldtia-forest.
Mesua-Palaquium forest
Schefflera-Gordonia-Meliosma forest
EVERGREEN FOREST
Disturbed forest and coffee plantations
MOIST DECIDUOUS FOREST
Lagerstroemia-Tectona Dillenia
DRY DECIDUOUS FOREST
Anogeissus-Tectona-Terminalia
RAINFALL REGIME
TROPICAL REGIME (With a single peak in July)
TROPICAL REGIME (With a secondary peak in October)
CLIMATE DIAGRAM
Altitude: 805 m
Annual Rainfall: 1701mm
Rainfall curve
PADINALKNAD GHAT
Alt: 210 m A.R: 5295 mm
MUNOROTE
Alt: 915 m A.R: 5097 mm
HALADI
Alt: 950 m A.R: 5263 mm
PALACE
Alt: 1400 m A.R: 4080 mm
KABINAKAD ESTATE
Alt: 975 m A.R: 2707 mm
KARADA
Alt: 923 m A.R: 2608 mm
VIRAJPET
Alt: 850 m A.R: 1803 mm
GONICOPPAL
Alt: 860 m A.R: 1522 mm
TITTIMATI
NAGARHOLE
Alt: 860 m A.R: 1491 mm
MURKAL
J M M J S N
mm
Altitude meters
1500
1000
500
100
0
RAINFALL AMOUNT (mm)
6000
5000
4000
3000
2000
1000
0
No. OF DRY MONTHS
5 4 3 2 1 0
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 Km
LEGEND
Annual average rainfall
Average number of dry months
Relief

Fig. 3. A WNW-ESE Oriented Climate – Vegetation Transect in the Kodagu district.

in relation to relief. The transect extends from Mundrote in WNW to Murkal in ESE (see Fig. 1) covering a distance of 80 km. The altitude increases from Mundrote to reach the high elevation of the Padinalknad Ghat at about 1500 m. Another peak is Kabinakad estate at 1400 m, east of which the topography is in form of a slightly undulating plateau with elevation under 900 m.

The rainfall curve which is over 5000 mm in the WNW decreases drastically in the lee of the crest of the Kabinakad estate. Over the plateau there is a gradual decline from 2707 mm at Karada to 1491 mm at Murkal. Parallel to this, the length of the dry season increases from 4 months (up to Gonicoppal) to 5 at Tittimati and Murkal. The rainfall régime (i.e. season of occurrence of rains) is tropical with a single peak in July up to Gonicoppal but Tittimati, Nagarhole and Murkal reveal a secondary rainfall peak in October besides the main peak in July. The vegetation pattern linked to these climatic factors (mentioned in Table 1) is depicted at the top of Fig. 3.

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REFLECTIONS UPON THE DISTRIBUTION OF INDIAN MAMMALS

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The study of the world-wide distribution of present day animals and extinct forms, has developed into the science of zoogeography. Why various creatures got where they are today, yet are not found in apparently suitable areas elsewhere, and why there are striking similarities between populations of animals occurring in widely separated places, are phenomena which have always intrigued biologists. As our understanding of this planet has increased, zoogeographers have developed more refined theorems to explain present day patterns of distribution.

The Indian sub-continent (taken here to include Pakistan, India, Sri Lanka, Bangladesh, Nepal, Sikkim and Bhutan), poses many fascinating problems because of its complicated geological history, and existing land connections with both southeastern Asian countries and also central Asian and western countries, at either end of the great Himalayan mountain barrier. In looking at the sub-continent's mammalian fauna from this perspective, it is helpful to keep in mind both the region's geologic history as well as some of the related fields of scientific study upon which zoogeographers depend.

Taking the first, one is at once aware of how many great time span gaps there are, in our knowledge of what has happened in the past. Mammals are of comparatively recent evolutionary origin compared with other life forms, with the first fossil evidence of mammal-like reptiles and primitive true mammals during the Jurassic period of the Mesozoic era, 180 million years ago (Davis & Golley 1963). But, most of the present day surviving taxa of mammals, especially at the present day generic level, arose much later during the later part of the Tertiary period, especially from the Pliocene (13 million years ago), up to the Pleistocene (less than 1 million years ago).

During the Tertiary period, the region was a separate island (the so-called Gondwana land), divided from the Asian land-mass by the great sea of Tethys in the northwest and a much more extensive northward stretching Bay of Bengal in the northeast. There were three great upheavals in the earth's crust during the Tertiary period. The first is believed to have resulted in the partial raising of the northern Himalayan regions, particularly in the eastern part, and is thought to have occurred during the Eocene epoch 50 million years ago. The result of this raising of the land was the creation of a land bridge between Gondwana and southeast Asia, particularly the Malaysian region, and this is considered to have enabled many of the present day mammals to colonise the sub-continent and to have given the region its predominantly Oriental Faunal characteristics. Later, a second upheaval occurred during the middle Pliocene epoch, about 13 million years ago and it is thought that this was of a more violent nature, creating the present day very high jagged Himalayan ranges (as well as the Alps in Europe). One result of this

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upheaval, was to create a physical barrier for the dispersal or movement of mammals northwards into central Asia, and also a climatic barrier for the warm moist monsoon winds, which resulted in the gradual dessication of the Tibetan plateau region, giving Ladakh and Baltistan their distinctive mammalian fauna, much of which is desert adapted. During the late Pliocene, less than 4½ to 3 million years ago, smaller upheavals or movements of tectonic plates, created an uptilting of the Himalayan foothill zone and thus produced the region known as the Siwaliks. These were originally sedimentary deposits laid down 25 million years ago by rivers draining into the sea of Tethys from the Himalayas. It is fortunate for Palaeontologists and zoogeographers that the richest source of fossil remains especially of mammals and birds, have always been found in water laid sediments and exploration in the Siwaliks have revealed a varied and fascinating range of fossils, showing that the sub-continent was once populated by mammals which are mostly extinct or whose modern descendants survive only within the continent of Africa. There were no less than 11 kinds of Elephants or Mastodons, six kinds of Rhinosceros as well as Giraffe-like mammals and Hippopotamuses (Prater 1965). Also many forms from the late Miocene which still have living counterparts in the sub-continent, such as Langurs (earliest fossil record, 5 million years ago), Macaques, true Cats, Foxes, Jackals, Sloth Bears and Ratels (Pilbeam 1979). Also such Rodents as the Bamboo Rats (Rhizomyidae), Bush Rats (*Golunda*) and Climbing Naked-tailed Rats (*Rattus* sp.) from the Pleistocene epoch (Jacobs 1978). There is evidence that the Sea of Tethys did not suddenly disappear, but continued as pockets of water, as a fossil whale from the late Pleistocene has recently been found near Kohat in the North West Frontier Province of Pakistan (Kidwai 1984), in a region which is on the western rim of the Siwalik zone. Also in the Punjab Salt Range (geologically part of the Siwaliks), fossil remains of *Ramapithecus* have been found, possibly the oldest recognisable ancestor of present day man (Pilbeam 1979).

During these epochs, it is also known that there were major climatological changes. Up to the Miocene epoch, 20 million years ago, the whole of the sub-continent was much milder and probably more humid than at the present time, with much more favourable conditions for life forms extending over the Tibetan plateau and the great Indian desert of Rajasthan.

Subsequently as the Himalayas rose, they became colder and in the late Pleistocene epoch the whole planet cooled down and there were successive periods of glaciation when parts of the Himalayas were covered by an ice cap and sea levels sank, due to lack of water run-off. It is presumed that many Palearctic mammals were forced to retreat southwards down to warmer climates, or perish, and that much of the Siwalik fauna disappeared due to climatic changes during this period.

Turning now to the second area of knowledge upon which the zoogeographer must draw, besides the fossil evidence of Palaeontology and a knowledge of stratographic geological history, our understanding has been sharpened by developments in the study of evolution and of taxonomy. Such relatively modern sciences as Ethology with interpretation of animal behaviour and biochemical systematics, particularly critical microscopic examination of chromosome numbers and egg albumen morphology etc. by the use of Gel electrophoresis has enabled the taxonomists to determine inter-specific relatedness, much more closely, sometimes between outwardly dissimilar species (Vuilleumier in Lack & Campbell 1985). The Palaeontologist constantly improves his ability to classify fossil remains, or recognise the probable ancestors of present day forms as our knowledge of taxonomy improves. Likewise the theory of tectonic plates has helped zoogeographers in our understanding of continental drift and geographic changes, which have in turn prevented or enabled animals to colonise different areas. Our increasing knowledge of genetics and evolution has also enabled us to realise that relatively small isolated populations can change quite rapidly, due to the selective pressures of the environment and the minute genetic changes which have more chance to persist in relatively small populations.

The Indian sub-continent is characterised as belonging to the Oriental faunal realm and this major zoogeographic sub-division lies mainly between 68° and 135° East and between 10° South and 32° North, being bounded on the west by Pakistan (mostly those parts east of the Indus River), in the north by the great Himalayan chain and including in the east, regions beyond the Himalayas such as southwest China, the Malaysian archipelago, western parts of Indonesia, the Philippines and Taiwan. All the land masses in this faunal realm show a certain degree of homogeneity in their higher vertebrate fauna. Though the Indian region has many mammals which are endemic or unique to the sub-continent, the majority share Malaysian affinities and typical examples are the Hog Badger (*Arctonyx collaris*), Tree Shrews (Tupaiidae), Lorises (Lorisidae), Lesser Panda (*Ailurus fulgens*), the Chevrotain (Tragulidae) (Mouse Deer), and the Serow (*Capricornis sumatraensis*). All these are typically Oriental faunal mammals not found in the Siwalik beds and presumed to have colonised India through that newly created northeastern corridor.

Compared with the Palearctic region to the north, the sub-continent has a more diverse fauna than Eurasia, but a much less varied fauna than the Ethiopian faunal realm. This illustrates an important principle determining species diversity and distribution. It is greatest in warm moist regions, such as the tropical and sub-tropical forest belts, and it is lowest in high cold (tundra and alpine), or hot dry (desert and arid zone) regions. The greater diversity of African mammals and birds is partly accounted for by its bigger land surface area, straddling both sides of the equator and providing a more varied rainfall and climate pattern, encouraging to some extent nomadism, which is typical of many of the African antelope species. About 40 percent of the distinctive mammalian groups in the Oriental region are shared with the Ethiopian faunal realm, whereas only 21 percent are shared with the Palearctic and a further 20 percent such as the Canidae (dog family), Mustelidae (Weasel family), Cats (Felidae) and Squirrels (Sciuridae), are considered to be world-wide in distribution (Davis & Golley, op. cit.). Consequently, within the Indian sub-continent itself we see the greatest diversity of mammal species in the moist tropical and sub-tropical forest belts, and the poorest numbers in the dry north-western regions. Among mammals adapted to mountain forest, we also see the greatest diversity in the eastern Himalayas, whilst the fauna of the colder dryer north-western Himalayas is much more restricted.

Another important principle governing distribution is that of barriers. These can be physical, such as sea or high mountains, or they can, on a longer time scale, be climatic barriers. Thus many oriental mammals of wide distribution in mountain forest could spread westwards along the Himalayas but could not penetrate the colder dryer extreme western forests nor down into the plains of India. The Goat Antelopes (Rupicaprinae) such as the Goral (*Nemorhaedus goral*), Serow (*Capricornis sumatraensis*) and Takin (*Budorcas taxicolor*) are examples, with all three occurring in the eastern Himalayas, but only the Goral extending as far west as Pakistan. Sri Lanka provides many fascinating examples of the 'island barrier' effect upon the distribution of higher animals. The sea was apparently too great a barrier for the Tiger to have reached, but the smaller hardier and more adaptable Leopard did so, as well as the Indian elephant, known to be a powerful swimmer. Sri Lanka has a less diverse and more limited bird and mammal population than the mainland, yet it has a higher proportion of endemic (unique) species, due to genetic isolation of relatively populations. There are seven endemic mammals, *Suncus zeylanicus, Crocidura miya, Solisorex pearsoni, Ferulus ferulus, Leolomys mayori, Srilankamys ohiensis, Mus fernandoi* and *Rattus montanus*, with three more confined only to Sri Lanka and the southern Deccan rain forest zone viz. *Loris tardigradus, Presbytis senex* and *Macaca sinica* (McKay 1984). Its bird fauna, with only 251 resident species compared with over 1,750 resident bird species in the rest of the sub-continent (S. D. Ripley 1982), is at the same time quite unique with no less than 21 endemic species (De Zylva 1984). For much the same reasons, we find that the two great faunal realms of Australasia and Neotropical, both have a much higher proportion of endemic species than the Oriental region. Moreover, as these regions are huge continent sized "islands", (South America was separated from North America by a water gap during the Tertiary), they have a very large and diverse fauna which shares practically nothing in common with the land mass of Eurasia.

Besides the isolating effect of islands or geographic barriers, we can see a converse effect in the former or continuing existence of land or water bridges, which actually aid in distribution. Typically Himalayan species such as the Himalayan Black Bear (*Selenarctos tibetanus*) and the Markhor Wild Goat (*Capra falconeri*) have been able to migrate southwards along the mountain ranges of Swat and Waziristan down into central Baluchistan and thus colonise a region much more arid and harsh than the rest of the Himalayas. Other examples of Himalayan species penetrating into central Baluchistan are such birds as the Streaked Laughing Thrush (*Garrulax lineatus*), the Black-crested Tit (*Parus rufonuchalis*) and Bar-tailed Tree Creeper (*Certhia himalayana*). Where mammals occur, as isolated disjunct populations, the causal reasons are often difficult to determine, but two or three previous conditions must have obtained in earlier times. Firstly, during an era of more equable climatic conditions, there must have been a continuous and widespread distribution of that particular species with no intervening gaps in its range. Secondly, competition with other species caused that mammal population to adapt and evolve specialised features enabling it to exploit a less competitive ecological niche. Thirdly, some geographic or physical barrier has intervened, such as unfavourable climatological changes. We know that the Alps and Himalayas both evolved in their present form in fairly recent geologic times. Presumably during an earlier period of more equable, possibly warm and moist climatic conditions, there was a continuous distribution of such mammals as Marmots (*Marmota* spp.) and Ibex Wild Goats right across southern Europe and Central Asia.

Subsequent climatic changes are presumed to have forced populations to retreat to high mountain plateau regions, possibly where there was less competition from other grazing mammals. Here in the European Alps and Himalayas quite disjunct populations continued to survive and gradually evolved into distinct species or sub-species. Anyone who has been fortunate enough to visit both the Alps and the Himalayas within the space of a few weeks, as I was this summer, would be struck by the very close resemblance in voice, habits and appearance of the Alpine. *Marmota marmota,* and the Himalayan *Marmota caudata* as well as *C. ibex ibex* of the Alps and *C. ibex sibirica* found in the Himalayas and Altai mountains. A third population of Ibex (*C. ibex nubiana*) has also survived in the high plateau regions of northern Sudan and southern Egypt. The classical case of the Tahr is less easy to understand. Ethological studies clearly demonstrate that this is one of the more primitive goats, from which the true goats of *Capra* genus are thought to have developed (Schaller 1973 & 1974).

There is no doubt that in earlier times before the late pleistocene, that the Tahr occurred widely as a continuous population. Fossil remains have been found in the Siwaliks and on Perim island near Bombay (Meinertzhagen 1928). Perhaps competition with more adaptable ungulates forced these goats to retreat and adapt to relatively precipitous mountain faces and later a period of unfavourable climate, probably of dry heat, forced them to retreat to higher mountain ranges where micro-climatic effects created some greater humidity and coolness. Whatever the causal reasons, one population was able to survive in the comparatively low hot mountain ranges of Oman and Saudi Arabia (recently rediscovered in that country), where a distinct species, the Arabian Tahr (*Hemitragus jayakeri*) has evolved. Another population retreated to the Nilgiri hills of south India (*Hemitragus hylocrius*), whilst a third, known as the Himalayan Tahr (*Hemitragus jemlaicus*), was able to survive in the Himalayas. Because of their comparatively earlier isolation they have evolved into three distinctive species in contrast to the 3 geographically isolated but closely similar sub-species of *C. ibex.*

Another important principle or theorem determining distribution is that of dispersal. This is based upon the known ability of living mammals to spread from their centre of origin, which can be studied from recent recorded human history. A good example is the spread during the 14th and 15th centuries of the Roof or Ship Rat (*Rattus rattus*) from the oriental region to western Europe and throughout many islands of the Pacific, with the advent of larger sized ships and intercontinental sea trade. Dispersal is only possible within a mammals ecological and physiological tolerances. Whereas a land tortoise can float on the sea and survive without food for as long as a month (and may have reached the Aldabra Islands that way), the example of Sri Lanka shows that many mammals cannot survive long sea crossings.

During one of the four glaciation periods of the Pleistocene, many mammals having a continuous distribution from the western Palearctic to Ethiopian regions, were probably forced to retreat southwards where they survived in warmer regions of the Middle East and the Mediterranean bordering countries. Probable examples were the Lion (*Panthera leo*), Caracal Cat (*Felis caracal*), Cheetah (*Acinonyx jubatus*) and Red Sheep (*Ovis orientalis*).

These animals were able to extend their range eastwards into the Indian sub-continent. The Cheetah became extinct in India as recently as 1948 (Van Ingen & Van Ingen 1948) and the Lion as is well known, now survives in an isolated pocket in the Gir forest with no intervening populations outside of Africa. It was not uncommon in the present regions of Israel and Jordan in Biblical times, whilst the last authentic specimen to be shot in Sind province, in what is now Pakistan, was killed in 1810 near Kot Diji (Kinnear, N.B., 1920). The disappearance of the lion from the intervening countries, in comparatively recent historic times, was undoubtedly due to competition with man and his domestic stock, in an otherwise comparatively arid and unfavourable ecological zone.

The comparatively cool climatic conditions with coniferous forests or sub-alpine scrub, which are found in the higher western parts of the Himalayas, have also enabled many palearctic mammals of the Boreal forest zone to colonise these regions. Examples of such mammals are the Lynx (*Felis lynx*), the Stoat (*Mustela erminea*), the Red Bear (*Ursus arctos isabellinus*) and the widely distributed Red Deer or Hangul of Kashmir (*Cervus elaphus hanglu*), which has evolved into a very large and distinctive sub-species.

Another important theorem developed by zoogeographers is called the "Centre of Origin". This states that animals disperse, or spread outwards, from a particular region which can be identified from the presence of the greatest number of related fossil forms (which are usually very limited), or from the present day greatest variety of living species. It is argued that such a centre is an area which provided the widest range of ecological niches and was a region of optimal habitat for that particular taxon. Over a period of time, evolutionary pressures and competition with other life forms, resulted in the greatest possible taxonomic diversity within that particular group of animals. There is some disagreement in the interpretation of this theory with one school of thought arguing that the most advanced and specialised, or adapted species, within a group, would occur in the centre of origin whilst the more primitive unspecialised members would occur mainly around the periphery of the centre of origin. Another school argues, more persuasively in my opinion, that as animals spread outwards they would encounter less favourable climatic or ecological conditions, which would exert upon them greater evolutionary pressure to adapt and modify their physical attributes. This would result in the more advanced or highly specialised forms occurring furthest away from their centre of origin (Darlington 1957). Probably both sets of factors have influenced animal dispersal and the resulting pattern of distribution is more complicated than can be explained by any single theorem.

The Himalaya, quite evidently, has the greatest species diversity in its Eastern range and it is logical to assume that plant and animal forms spread westwards from the northeastern corner, gradually diminishing in diversity as they reached the western boundary of the Himalayas (Meinertzhagen 1928). It is easier to draw upon examples of this phenomenon from the plant and avian kingdoms, as the variety of mammal species is so much smaller, and mammals themselves have more ability to adapt to different conditions. For example, there is only one Rhododendron species (*Rhododendron ferrugineum*) found wild in the European Alps and only two in the Pakistan Himalayas (*Rhododendron lepidotum* & *R. arboreum*) (R. Stewart 1958), whilst Nepal has over 30 different species

(Polunin & Stainton 1984). Similarly there are only 3 species of Laughing Thrush of the genus *Garrulax* found in Pakistan today (*G. lineatum, G. variegatum & G. albogularis*), whilst there are 15 in Nepal (Inskipp & Inskipp 1985). Amongst mammals, perhaps the best example are the Goat-antelopes of the tribe of Rupicaprinae, which has already been cited at the beginning of this article.

It would be difficult in a short article of this nature to cover all factors which have contributed in India's unique pattern of mammalian distribution and an excellent summary of zoogeographic origins and history of the sub-continent is given in the Introduction to Volume I of Handbook series (Salim Ali and S. D. Ripley 1968).

The great riverain systems of the Indus and Brahmaputra/Ganges undoubtedly provided favourable habitat for the evolution of swamp-dwelling animals during periods of drier climate and there has arisen a number of endemic species unique to this region. Quite early on, human settlement coupled with subsequent changes in the course of rivers has led to diminution of suitable swampy areas and the division into two similar but widely separated tracts of tall cane grass and seasonal swamp. One, along the Indus river and the other now mainly confined to the more eastern Himalayan sub-foothill zone, known as the Duars or Terai. Here distinct sub-species have evolved such as the Blind Dolphins, *Platanista gangetica* and *Platanista indi* (Roberts 1977) as well as birds like the Long-tailed Grass Warbler (*Prinia burnesii burnesii*) of the Indus and *Prinia burnesii cinarescens* of the Terai. Even in recent times the Great Indian Rhinoceros (*Rhinoceros unicornis*) survived in the riverain tracts of the upper Indus, as revealed in the diaries of the great Moghul Emperor Babur who hunted this animal in 1526 on the Kabul river near Peshawar and in the area which today forms part of lower Swat in Pakistan (Babur-i-Nama, trans. Beveridge 1921). Today it survives only in pockets along the Duars and Terai in the foot of the eastern Himalayas.

There are many intriguing facets of mammalian distribution still difficult to explain. Why does the sub-continent have comparatively few, (5, if we include the Tibetan Chiru *Panthelops hodgsoni*) antelope related species, four of which are uniquely endemic to the region? These are the Nilgai (*Boselaphus tragocamelus*), the Blackbuck (*Antelope cervicapra*) and the Four-horned Antelope (*Tetracerus quadricornis*) and the more widely distributed Chinkara gazelle (*Gazella gazella benneti*), all adapted to rather arid savannah or thorn forest ecosystems. By contrast the Ethiopian region has over 72 different species of gazelle, antelope and Reed-buck (Dorst & Dandelot 1970). Except for the Barbary Stag (*Cervus elaphus barbarus*) which occurred in Algeria, north Africa, outside of the true Ethiopian realm, Africa has no deer species (Cervidae). Yet the Indian sub-continent has nine, if the primitive Chevrotain and Musk Deer are included. Undoubtedly deer are of ancient origin, with fossil forms first appearing in the lower Miocene (Prater 1965), and they are believed to be mainly of old world origin, and to have developed in Eurasia rather than in tropical regions. Moreover, most are adapted to live in forest, or a more sheltered vegetative cover than the open grasslands typically favoured by antelopes.

As will be seen, this account raises more questions than it provides answers and our conclusions about mammalian distribution in the region still remain highly speculative. Every step forward in our knowledge about the physiology and habits of present-day Indian mammals and their ecological requirements will undoubtedly throw more light on these fascinating questions.

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CONSERVATION OF WILDLIFE IN TAMIL NADU

E. R. C. Davidar[1]

The recent history of Wildlife Conservation in Tamil Nadu dates back to the Nineteenth Century when the State was part of the Madras Presidency. This Province encompassed within its boundaries the whole of Tamil Nadu and parts of Kerala, Karnataka and Andhra Pradesh until the Indian Union was reorganised into smaller linguistic units in 1956. Conservation began with the implementation of the Madras Forest Act of 1882. The objective of this enactment was to declare and define the boundaries of Government forests and safeguard them. Affording protection to the habitat of wildlife, the first step in any conservation programme, was achieved thus. Wild birds and animals protection 1912 was the next step.

The emphasis then was not so much on conservation, as the concept has come to be understood, as on exploitation. But then there was a method to such exploitation. Forests were divided into blocks and worked and rested at regular intervals. Similarly, wild animals and birds, particularly those that were classified as "game" were allowed to be harvested. Apart from the written rules, there was an unwritten 'Sportsmen's Code' that was observed fairly strictly. There were revenue and private forests where free hunting was to be had. Rulers of Indian States and Zamindaris exercised control over their forests; the degree of such control varied depending upon the ruler's interest in shikar. Compared to some parts of India, the extent of this class of forests was small in the Madras Presidency. The bulk of wild animals and birds lived within the confines of reserved forests and enjoyed a fair degree of protection.

However, as far as predators were concerned, apart from the general protection, they received by residing within reserved forests, they were at the mercy of game licence holders. There was a notion at that time that predator and prey cannot co-exist and that the predator must be eliminated if game animals and birds were to thrive. Tigers and leopards were classified as vermin and rewards were paid for their destruction. And dhole were out and out outcastes. The same applied to the lesser cats, mongooses etc. But predators managed to survive mainly because the methods employed against them were generally fair and sporting.

Wild elephants came in for special protection under the Wild Elephants Protection Act of 1876, a Central Act. However, during World War II, crop raiding elephants were allowed to be shot freely in cultivated areas as they were believed to interfere with the 'Grow More Food' campaign.

Poaching fell into three categories, namely, the Village poacher with his blunderbuss, the poacher from urban area who had local influence and the official poacher. There was no large scale poaching. Poisoned baits and the like were unknown. It was after the war with the advent of jeeps and spotlights when hunting became safe and easy that armed gangs from cities went into forests and ravaged them. And hunting ceased to be a sport except for the diehards from the old school.

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This was more or less the general situation that obtained in South India and for that matter throughout the Indian sub-continent.

Some areas in Tamil Nadu enjoyed a special status, which was unique in many respects and deserve special mention.

Nilgiris: The Nilgiri mountain did not come to the notice of the British and the outside world until the eighteen twenties. Its salubrious climate and scenic beauty brought a procession of European settlers and vacationers. The hunters among them called it a 'Sportsman's paradise' and unleashed a war on its wild animals and birds on a scale never equalled before or since. As weapons improved it became a slaughter and for miles around each hill station in ever widening circles game was annihilated. Some species such as the Nilgiri tahr were brought to the brink of extinction. Appalled at the state of affairs a band of fair minded sportsmen decided to act to stem the rot. In 1877 they established the Nilgiri Game Association with the object of preserving game and fish in the Nilgiris. Their very first action established their bona fides. It was to impose restrictions upon themselves by way of close seasons, bag limits, banning hunting of females, calves and immature males. Then they approached the Governor to give legislative form to their action. The Duke of Buckingham, the Governor not only accepted the NGA's recommendations, but acted promptly. In 1879, the Nilgiri Game and Fish Preservation Act, a state enactment, the first of its kind in India was passed. The rules empowered to the Collector (the head of the district) to administer the Act. He invited the NGA to advise and assist him in implementing the Act. The District Forest Officer was elected Honorary Secretary of the Association and the administrative functions were carried out by an Honorary Superintendent, who was elected from among the members of the Executive Committee. In this manner, an ideal working arrangement in which officials and non-officials co-operated, was brought about. This happy situation was soon reflected in the field. Nilgiri tahr, for instance, were brought back from the brink to a state where it was possible to permit the hunting of saddle backs. Game showed allround improvement in status. Despite unrestricted hunting of predators these too seemed to thrive. Preservation of game was achieved through management of hunting.

Palani hills: An Association known as the Palani Hills Game Association was formed on the lines of the NGA. It functioned well for a while, but soon lost its vigour as it lacked dedicated membership and ceased functioning altogether.

Game associations promoted sportsmanship and fair play in hunting which contributed in no small measure to the preservation of game. These values have endured.

When Tamil Nadu State came into being ten years after Independence, the post war rot had already set in. It became fashionable for the new rich, who lacked sporting values and tradition to indulge in shikar to satisfy their egos. Jeeps and spot lights made things easy. To make matters worse the State Government closed some well stocked forests to hunting to give them rest, but without strengthening the protection machinery. What happened in fact was the opposite of what was planned.

Another shortsighted move was the banning of hunting of tigers and leopards without preparing the ground for such a move. Affected cattle owners were left with no option but to take the law into their own hands to protect their property. Folidol, a potent insecticide was freely available and cattle owners resorted to poisoning kills. Tigers and leopards that had learnt to outwit the hunter could not cope with poisons and whole families perished.

However, before it became too late, the Tamil Nadu Government took certain steps that arrested the trend and they went a long way towards promoting wildlife conservation. A Wildlife Advisory Board was set up in the Nineteen sixties. It was a representative body on which people and organisations holding a wide range of views were accommodated. A separate officer designated, State Wildlife Officer, was appointed to look after the interests of wildlife. Steps to promote wildlife preservation consciousness were initiated. Sanctuaries were established and protection tightened up. A scheme for compensating villagers who lost their cattle to tigers and leopards was introduced.

Most States are ostrichlike in their attitude towards hunting. They ban hunting, bury their heads in their paper orders and pretend that all is well. Tamil Nadu is one of the few States that follows a pragmatic policy. Wild pigs and small game in some Reserved Forests and outside are allowed to be shot by game licence holders. This policy has eliminated poaching to some extent.

National Parks and Sanctuaries:

Tamil Nadu has a land area of 1,30,069 sq. kms. of which only 20,910 sq. kms. or 16% is forest and sanctuaries occupy about 2,500 sq. km. or 12%. Although the area under sanctuaries and some sanctuaries themselves are small, the range is truely remarkable. Coral reefs, mangrove swamps, coastal forests, fresh water lakes, open plains, mountains and forests of various kinds including tropical wet evergreen forests and evergreen sholas are included in this range. As may be expected, the range in wild animal and plant life is equally wide. To describe some of the principal sanctuaries briefly.

The Guindy National Park: This tiny park of 2.8 sq. km. which forms part of the Government House Estate within Madras City limits is the only National Park in the State. It has an overflowing black buck and spotted deer population.

The Mudumalai Wildlife sanctuary: Situated in the Nilgiris, 65 Km from Ooty on the Ooty-Mysore highway, Mudumalai, established in 1940, is the oldest sanctuary in the State and one of the first to be set up in India. Its present area is 321 sq. km. The average elevation is 1,000 m. Mudumalai is contiguous with the Bandipur Tiger reserve in Karnataka and the Wynaad Wildlife sanctuary in Kerala. Moist and dry deciduous forests predominate. Teak, naturally grown as well as raised as plantations is the principal tree species. Elephant and gaur are the main attractions. Tigers, leopards and wild dogs are the large predators. the last named is by far the most visible and destructive of the three.

Anamalai Wildlife Sanctuary: This is the largest wildlife refuge (958 sq. km.) in the State. From the plains of Coimbatore, the sanctuary ascends all the way to Grass Hills in Valparai Taluk situated at a height of over 2,000 m. Topslip is the focal point. Nilgiri tahr and lion-tailed macaque both endangered are the main attractions. Birds of the plains as well as hill birds are found in this sanctuary.

Mundanthorai and Kalakadu sanctuaries: Mundanthorai (567 sq. kms.) and Kalakadu (223 sq. kms.) are contiguous. Different forest types including tropical wet evergreen forests occur. Kalakadu is well known for its population of liontailed macaques.

Point Calimere: Calimere is the point projecting into the Bay of Bengal on the south eastern coast line of India just above Sri

Lanka. Point Calimere was made into a sanctuary mainly to protect the herds of black buck and spotted deer inhabiting the coastal forests and plains there. After the N. East monsoon the place comes alive with water birds as flocks of waders and ducks species some from up country and the rest from across the Himalayas, in some cases from as far north as Siberia congregate to spend winter or to use it as a staging point in their migration to Sri Lanka.

Mukurti : The wild country along the western edge of the Nilgiri plateau consisting of rolling grass hills interspersed with evergreen sholas of the southern montane wet temperate type and bounded on the west and south by awesome precipices, the home of Nilgiri tahr has been made a sanctuary and named after the most striking physical feature there, the Mukurti peak. It has great scenic beauty, unique animal and plant life and a cold brazing climate. Some plants, animals and birds of this region have their nearest congeners in the Himalayas lending support to the theory that at one time in the earth's development there was a connection between the two regions.

Vedanthangal : This is a waterbird sanctuary situated 70 km from Madras. It is one of the best heronries in the country, patronised by cormorants, grey herons, open billed storks, spoonbills and others. Many species of migrant water birds choose Vedanthangal for their winter sojourn.

There are some more water bird sanctuaries in the State. Megamalai in Madurai district to protect giant squirrel of the grey variety (*Ratufa macrura*) and Nilgiri tahr; Gulf of Mannar (Kurusadi islands) to protect coral beds; and rich marine life there; Pichavaram, to protect mangrove swamps, are some of the recently formed sanctuaries.

Status of wild life:

PRIMATES: Lion-tailed macaque — The small populations found in the State in Kalakadu and Anamalais are well protected. They have been the subject of intensive research.

Nilgiri langur — In well protected areas they are on the increase. Poaching is a problem in remote areas. Common langur — In the south these monkeys are confined to forested hills where due to predation and other causes their numbers have not increased. Bonnet macaque — They are proliferating and need some form of control particularly since they destroy crops or orchards.

ELEPHANT: According to the April 1983 count there were 2179 elephants in Tamil Nadu. The trend shows a steady increase. As against this situation, the problems faced by elephants are many. Shrinking habitat due to destruction and degradation of elephant forests and fragmentation leading to 'pocketing' of sub-populations are the most serious among the problems. Ivory poaching besides being an evil by itself is causing anxiety because of the scale of such poaching and the long term effect it is bound to have on elephant populations such as, imbalance in sex ratio and genetic degradation due to loss of fine breeding bulls. At this rate it is feared that in a few years time hardly any tuskers will be left.

GAUR: Gaur are on the increase in suitable areas. Habitat destruction and denudation is a problem they share with elephants. Gaur are subject to periodic outbreaks of rinderpest in epidemic form, no doubt brought into the jungle by domestic cattle. And there seems to be no way of keeping cattle out of even sanctuaries because of political pressures. A good development is the practice of protecting domestic cattle against rinderpest.

NILGIRI TAHR: Nilgiris and Grass hills in the Anamalai hills hold largest populations. Population trends reveal that optimum levels have been reached. There are small populations scattered over isolated hill tops and ridges. These face a bleak future. There are a few populations on the eastern face of the Western Ghats in the Anamalais hills which are thriving in low level habitats where the vegetation is of the dry deciduous scrub type. Protection is a problem where isolated, outlying populations are concerned. Tahr have had to yield ground before Hydroelectric projects, eucalyptus and wattle plantations and developmental work in the name of hill area development.

DEER: *Sambar* — In well protected areas sambar are on the increase. *Spotted deer* — where wild dogs are operating, numbers have declined. *Barking deer* — They seem to be holding their own in suitable country. *Mouse deer* — As they are nocturnal it is difficult to make an assessment. Indications are that they are doing alright.

ANTELOPE: *Black buck* — The status of these antelopes has improved and they are expanding their range. *Four-horned antelope* — They are rare and always have been.

WILD BOAR: In many areas their natural enemy, the leopard has disappeared leaving only man. Cultivators have been protesting against giving protection to pigs. However, the Government by permitting hunting of pigs on licences in some areas has been taking the pressure off the demand to scrap the Wildlife (Protection) Act itself.

TIGER: In spite of official claims, there has not been any significant improvement in the status of tigers. But there has been a rather slow and steady improvement since the nineteen sixties. Easy access to potent pesticides continues to be a cause for concern.

LEOPARDS: Leopards are on the increase in well protected areas and frequently wander outside reserves into towns and villages and cause problems for themselves and humans.

WILD DOGS (DHOLE): In certain areas such as Mudumalai, they are fairly numerous and have been causing havoc among spotted deer. They have also taken to killing domestic stock and invite retribution usually through poisoning of kills.

SLOTH BEAR: Bears have few natural enemies and habitat destruction is the main obstacle standing in the way of their conservation. Where bear habitat has been left undisturbed, these animals have increased.

STRIPED HYENA: It is not difficult to locate hyenas through their dens. This makes hyenas highly vulnerable to attack particularly where their habitat is subject to degradation. The once common hyena is uncommon now.

LESSER PREDATORS: No serious attempt has been made to census or survey small mammalian predators, such as jungle cats, leopard cats, the various mongooses and others. Official records where they exist are open to question. Ratels are rare. Less is known about the distribution and status of the high elevation fauna, such as the Nilgiri marten. Status survey of the different species of otters has also not been attempted.

PANGOLIN: Reports show that they continue to be rare. Jackals, fox: Foxes are fewer; pressure on land being the cause. Jackals are adaptable and have been managing to survive.

BLACK-NAPED HARE. Tribals, both resident as well itinerent have been exerting pressure on the hare through hunting and netting. These adaptable animals have been managing to survive where adequate cover is available.

BIRDS: Game birds such as partridges and quail and waders continue to be hunted and netted by Narikoravas, an itinerant tribe. And game birds and hare are openly sold by them in towns and villages. Peafowl enjoy greater protection due to sentiment and are increasing. Grey jungle fowl are generally on the decline, but are thriving in suitable localities. The same is the case with the red spur fowl. Painted spur fowl are rare. Fruit eating birds are the worst sufferers when forests and groves are felled. Their decline in number is apparent.

REPTILES:

Marsh crocodile or muggur — There are still a few places in the State where crocodiles are found in the wild. Crocodile breeding through collection of eggs of wild crocodiles and hatching them in hatcheries has been successfully tried out in Tamil Nadu.

Snakes — Tanneries in the State have proved to be collection, curing and despatch centres for snakes skins from all over the country. In spite of periodical raids and seizures, the trade has not come to a stop. Some tribals also indulge in the trade as snake catchers. For how long snakes will be able to stand this onslaught is anybody's guess.

Turtles, terrapins and tortoises — Fortunately for the sea turtle, few people in the State have developed a taste for its flesh. This cannot be said for terrapins in tribal areas. Olive Ridley is the commonest sea turtle. Fewer tortoises are met with. Habitat destruction is the principal reason for the fall in numbers of terrapins and tortoises.

The Chief Wildlife Warden, a senior forest official is the enforcing authority under the Wildlife (P) Act. He has his office at No. 571 Trichy Road, Coimbatore. Each major sanctuary is under the control of a Wildlife Warden. Regrettably dual control still exists.

The Wildlife Department has set up crocodile farms at Mettur, Amarvathi, Sathanur and other places where crocodiles are bred and reared. Crocodiles have been brought from the brink of extinction to a state where they have put officials in a quandary due to over production. Sea turtle eggs are collected when gravid females come ashore and lay eggs saving them from predators such as dogs, jackals and humans. The eggs are hatched in a central place and hatchlings released into the sea. This scheme has been in operation for the past five years or so and has been quite successful.

Tamil Nadu is fortunate in having dedicated local conservation organisations to augment the Government's efforts in this direction. To name the important ones — Nilgiri Wildlife and Environment Association, the Madras Snake Park, the Madras Crocodile Bank, the Irula Snake Catchers Co-operative (which has been established to wean away Irulas from killing snakes for their skins, to catching them for the extraction of venom; the snakes being released into the wilds after venom extraction), Madras Naturalists Society, Tirunelveli Wildlife Preservation Society, Ramanathapuram Wildlife Society etc. There are colleges in the State offering marine biology and wildlife biology degree courses.

It must be said to the credit of the Tamil Nadu Government that it has been following an enlightened policy by encouraging naturalists and wild life researchers to work in its sanctuaries. It can take credit for providing facilities to the Bombay Natural History Society to run a bird banding and research centre at Point Calimere which has been doing excellent work. The Tamil Nadu Government is one of the few Governments to appoint hunters as Honorary Game Wardens thus associating hunters in conservation efforts.

The Forest Conservation Act, the Nilgiris Biosphere Reserve proposal, the policy decision of the Tamil Nadu Government to abandon clear felling and in some cases even selection felling in sanctuaries and other progressive measures augur well for the conservation of wildlife. The Wildlife (Protection) Act deserves to be better known. Most of the offenders are not aware of the implications of the Act. Tree felling laws applicable to privately owned trees and groves are negative in character. What is needed is a positive thrust to encourage raising trees through private initiative.

The mounting pressure on forests and forest produce due to unbridled increase in human population is going to be the real challenge in the years to come. To meet this challenge, not only are imaginative measures needed, but the strength of the wildlife staff needs to be increased in proportion to the wide scope and ambit of the law which is their responsibility to enforce.

ADAPTIVE SPECIALIZATION IN RELATION TO NICHE DIVERSITY IN PHYTOPHAGOUS AND MYCOPHAGOUS THRIPS

T. N. Ananthakrishnan[1]

(*With three plates and a text-figure*)

Thrips species like many other insects tend to maintain an understandable degree of stability, irrespective of their habits — whether phytophagous, mycophagous, cecidicolous or predatory, through evolving optimal behavioural strategies or adaptations in view of their ability to compete for resources, as well as for mates, emphasising the importance of resource utilisation and mating competition in the successful survival of a species (Ananthakrishnan 1984). As the number of locally coexisting species tend to differ from place to place, their abundance tends to fluctuate with time, and the distribution of individuals among these species also varies with different localities, communities and populations. Natality/mortality schedules also play a pivotal role in maintaining the stability and survival probabilities of fluctuating populations. Studies on other phytophagous/mycophagous insects like other animals have also shown that fluctuations in the environment, predation/parasitisation, presence and availability of food, are related to community structure. The operation of 'r'-selection in an uncrowded or unstable environment is evident when a species can maximize its growth rate, while k-selection at the other extreme involves maximizing its competitive ability when in a crowded state. Both are equally typical of thrips species inhabiting diverse habitats. The tendency for generalist-specialist demarcation is equally well evident, the specialist being more restricted in its niche-width, the generalist having a wider niche-width, more intraspecific competition and polymorphism and better utilisation of food and consequently of increased reproductive success.

An interesting aspect of thrips is their ability to adapt to varying environments, the abundance of phytophagous species being correlated with particular types of plant formations. Many terebrantian species infesting leaves of plants show a vertical distribution or stratification, inhabiting different nodes thereby avoiding competition. Many others are known to form galls or malformations in plants and yet others are predatory feeding on aphids, coccids, thrips, mites etc. Some are essential elements of the edaphon occurring as prepupae and pupae upto a depth of 10-30 cms. in the soil, while dead and decaying vegetation, bark, litter harbour several mycophagous species.

For an understanding of the behaviour of phytophagous thrips communities, a prerequisite is an understanding of their distributional patterns on the leaves or flowers of the concerned plants. Very often adult and nymphs of a single species are known to occupy different nodal leaves of the same plant. It is also known that as many as seven species of

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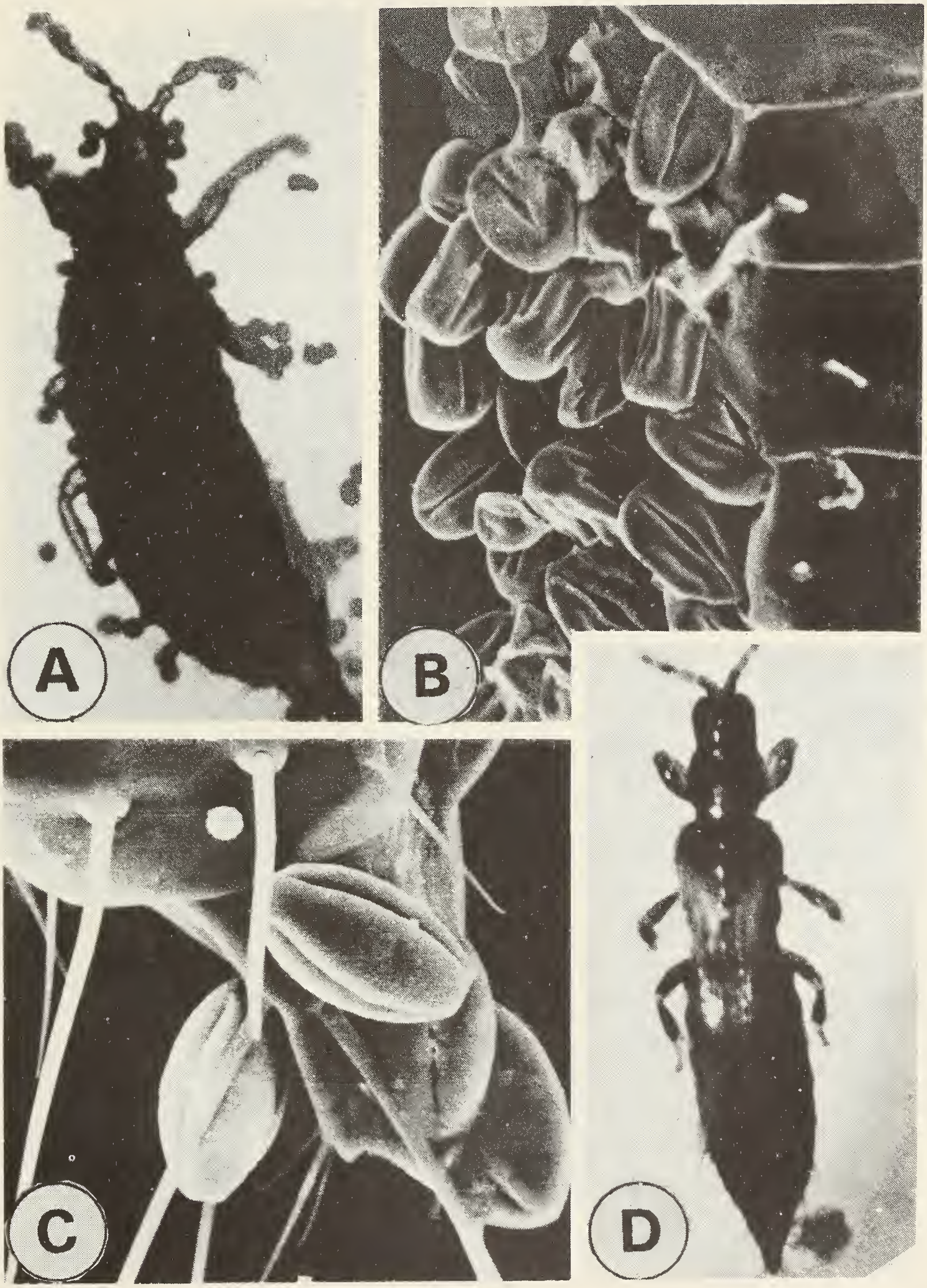
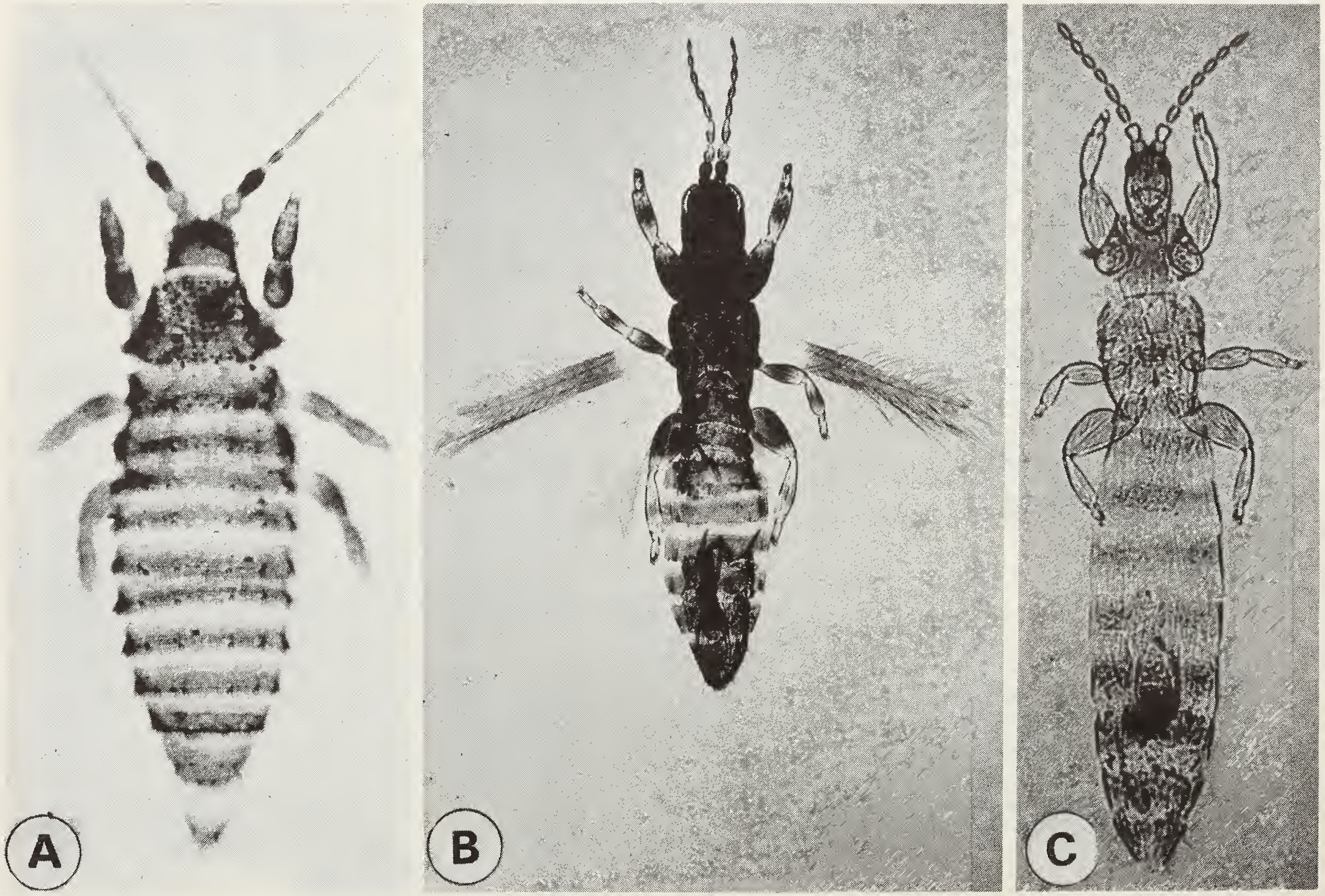


Thrips in pollination.
A—An immature stage carrying pollen. B, C—Scanning Electron Micrographs showing pollen attachment to setae. D—Adult thrips with a mass of pollen.



Primitive mycophagous Terebrantia.
A—*Uzelothrips.* B—*Erotidothrips.* C—*Merothrips.*

thrips occupy different nodes of single host plant avoiding competition and this is evident in the common castor plant *Ricinus communis* (Ananthakrishnan 1984). Added to this, ecological succession of different thrips species infesting flowers is also known, leading to the recognition of primary, secondary and tertiary inhabitants as evident in the flowers of *Ruellia tuberosa* (Viswanathan & Ananthakrishnan 1976). The phenology of thrips assemblage in terms of abundance and flower preference is equally typical of several species. Ecological succession as well as species packing with as many as four species within a single flower or inflorescence is also known. The ability of thrips to carry sufficient quality of pollen grains of a variety of flowers during their flight tends to promote cross pollination, the efficiency of pollination naturally depending on the size, viscosity of the pollen grains, attractiveness of the flowers as well as the number and species of thrips present. The number of individuals present in the flower as well as the amount of pollen grains per insect would determine the pollen load or the total amount of pollen that they carry, on the thoracic and abdominal setae as well as on the wing setae, fringes and antennae. As such species with well-developed setae such as those of *Frankliniella* tend to be more efficient carriers of pollen. The maximum number of pollen grains carried is around 200 per thrips in *Frankliniella schultzei* inhabiting Compositae flowers (Ananthakrishnan 1982) (Plate 1).

It is now well presumed that the Thysanoptera evolved from insects in which both the mandibles were reduced and the asymmetry resulting from the enlargement of the left mandible was associated with pollen feeding. In view of the fact that most thripids feed on vascular plants and pollen, a correlation of the development of the left mandible with the corresponding reduction of the right, so that the single mandible served as a more efficient tool for piercing the pollen. It was therefore inferred that the evolution of thrips occurred through pollen feeding and until the angiosperms evolved, thrips could have fed only on gymnospore pollen and spores. In this evolutionary advancement, the tubuliferan thrips developed longer maxillary stylets, invaded the saprophytic fungal zone and proliferated within diverse fungal niches. Of particular interest is the recognition of three groups of mycophagous species, the first which retained the short maxillary stylets, the second developed the tendency for flexible maxillary stylets, developing complex convolutions and third producing thicker stylets, developing the tendency to feed on spores, so that we have the mycetophagous and sporophagous species among the mycophagous group (Ananthakrishnan 1979, Mound 1977a, 1977b; Mound and O'Neill 1974).

Such microhabitats invaded by mycophagous species enjoy a relatively constant environment, more particularly in the Tropics, so as to enable easy mingling of individuals. In such situations the rate of speciation is reduced, besides increasing the chances of survival of relict species such as the more primitive fungus feeding *Uzelothrips, Erotidothrips* and species of *Merothrips.* (Plate 2). The impact of habitat fluctuations and food combined with other related factors, both internal and external have contributed to the evolution of wing polymorphs as well as the production of a structurally diverse series of forms, the gynaecoid and oedymerous males and major and minor females favouring equally diverse mating patterns and associated differences in fecundity. What is striking about the incidence of sex-limited polymorphism is the degree of phenotypic flexibility which is more typical of mycophagous species and the ability of the genotypes of the concerned species to produce a range of varying phenotypes, through variation in the degree of expression and suppression of one or more characters, which could possibly be explained as due to pleiotropy and polygeny (Ananthakrishnan 1973, 1979, 1984).

Several species of mycophagous Tubulifera have developed the tendency to aggregate, the nature of aggregation and population size mostly depending on fungal food availability which in turn depends upon the environment (Plate 3). As for their food, the phlaeothripines feed on fungal mycelia imbibing their contents, while the idolothripines consume spores and so are essentially sporophagous. Feeding on spores involves contraction and dilation of cibarial and pharyngeal muscles followed by a rapid wafting action through the development in many species of a 'wafting comb' comprising diverse types of long or short inward processes of the muscular wall of the foregut, especially in species feeding on large, single to many celled, thick-walled spores with dense pigment. The maxillary stylets in the mycetophagous species range from 0.85-1.7 μ wide with pointed apices, while in sporophagous idolothripines they are 5-14 μ wide exhibiting considerable variation distally. As such feeding diversity in respect of fungal resource utilization in diverse ecological niches is very typical of sporophagous idolothripines, enabling recognition of the following distinct fundamental categories.

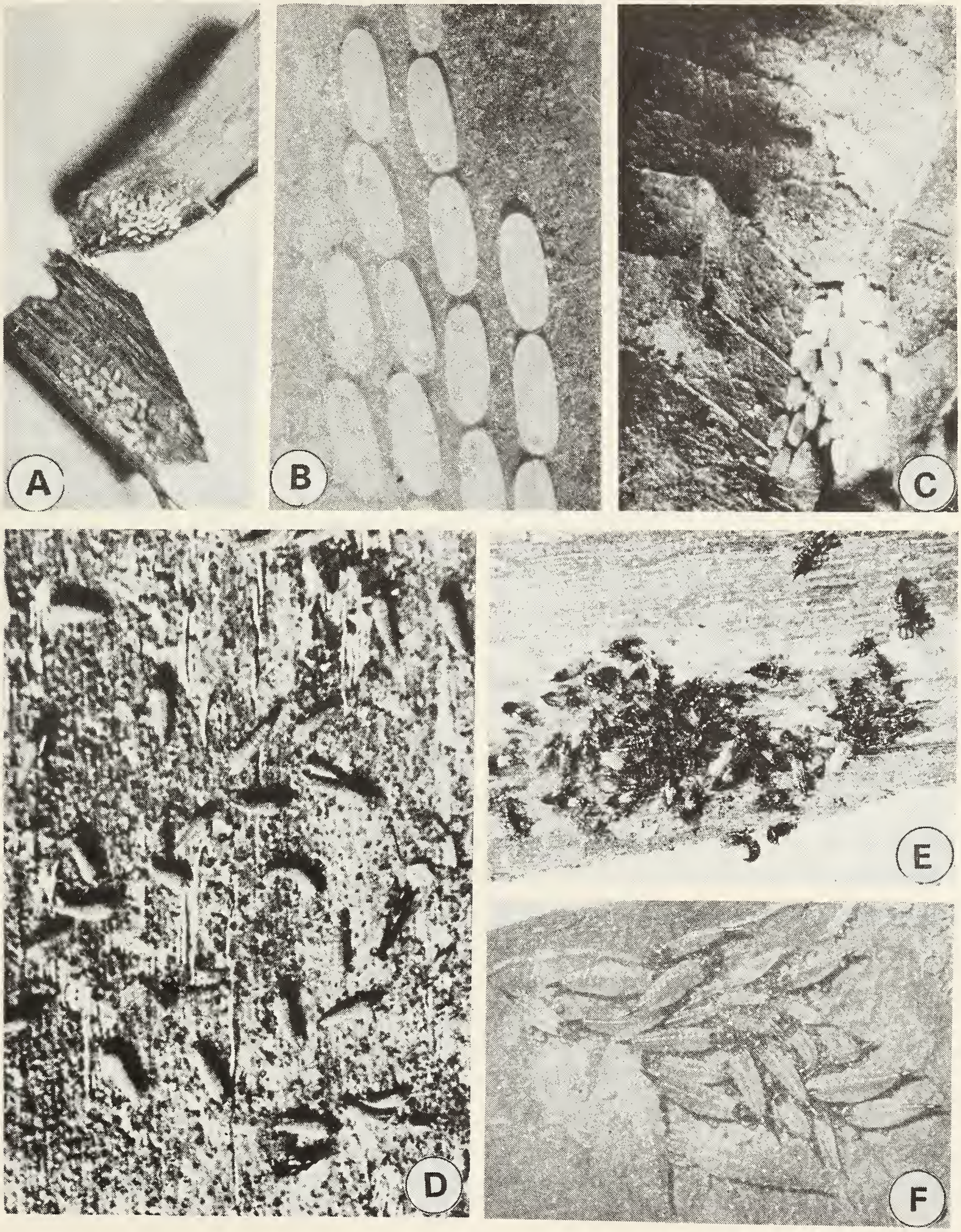
(a) Species which exploit various hosts for fungal food resources, but feed only on the spores of one and the same fungus. Example: *Dinothrips sumatrensis* feeds only on the spores of *Lasiodiplodia theobromae.*

(b) Species which are host specific, but feed on a wide variety of fungi present, involving all the major categories, Ascomyctes, Coelomycetes and Hyphomycetes. e.g. *Tiarothrips subramanii* feeding on *Anthostomella consanguinea, A. sepilibilis, A. phoenicicola, Pestalozzia algeriensis, Melanographium citri.*

(c) Species with a restricted host range and restricted feeding, e.g. *Elaphrothrips denticollis,* occurring in large numbers in drying leaves of *Areca catechu* and *Tectona grandis* feeding on the spores of *Pestalozzia algeriensis* and *Phomopsis tectonae* and *Bactrothrips idolomorphus* on dry leaves of *Shorea robusta* feeding on *Pestalozzia* and *Lasiodiplodium.*

(d) Species occurring on a wide range of hosts, mostly drying grass clumps, feeding on a wide range of fungal spores as in *Loyolia indica.*

Adaptive diversity in terms of reproduction is well developed in sporophagous species, all phytophagous species reproducing only by oviparity involving both sexual and parthenogenesis reproduction in many cases, mostly in Terebrantia and only by the sexual method in the others. While oviparity is very typical of mycophagous species, several sporophagous species show varying degrees of oviparity, ovoviviparity and viviparity. The type of reproduction, whether oviparous or ovoviviparous, is determined by factors such as environment, fungal food availability, aggregation and oviposition behaviour (Fig. 1). Oviparity occurs during the more-moist months when sufficient fungal food is available and a longer incubation period does not result in dessiccation, the patterns of oviposition varying with species. In the drier summer months, reproduction involves the graded types of ovoviviparity and viviparity thus enabling protection of the eggs from desiccation and overcoming the fungal food scarcity. Viviparity and



Aggregation patterns of adults and oviposition patterns in some mycophagous thrips. A—Egg mass of *Ecacanthothrips*. B—Egg laying pattern of *Tiarothrips*. C—Egg laying pattern of *Ethirothrips*. D—Adult and immatures of *Ecacanthothrips* on bark. E—Adult of *Priesneriana* on bark. F—Aggregation of insects of *Tiarothrips*.

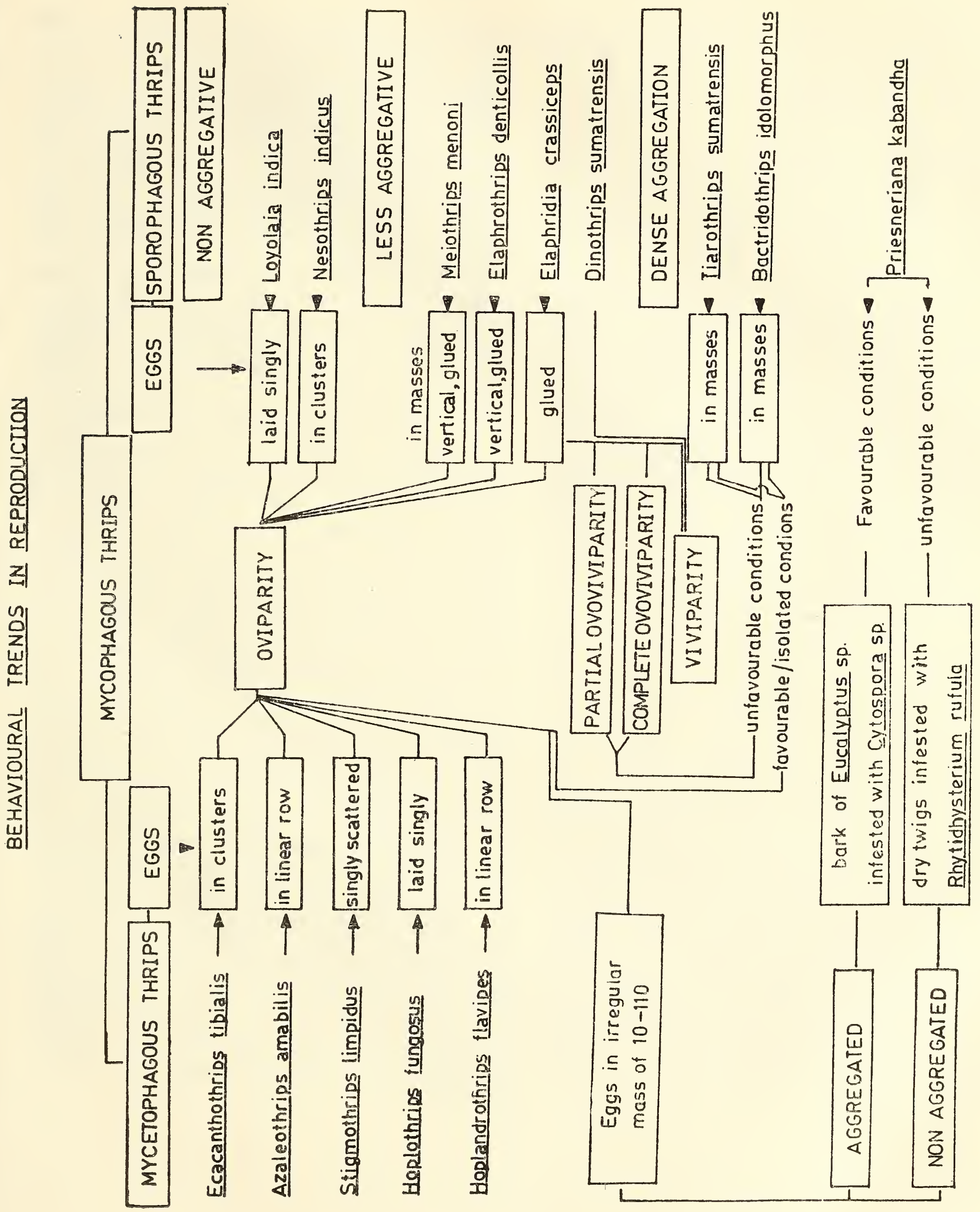

BEHAVIOURAL TRENDS IN REPRODUCTION
MYCOPHAGOUS THRIPS
MYCETOPHAGOUS THRIPS
EGGS
SPOROPHAGOUS THRIPS
EGGS
NON AGGREGATIVE
Ecacanthothrips tibialis
in clusters
Azaleothrips amabilis
in linear row
Stigmothrips limpidus
singly scattered
Hoplothrips fungosus
laid singly
Hoplandrothrips flavipes
in linear row
OVIPARITY
laid singly
Loyolaia indica
in clusters
Nesothrips indicus
LESS AGGREGATIVE
in masses
vertical, glued
Meiothrips menoni
vertical, glued
Elaphrothrips denticollis
glued
Elaphridia crassiceps
Dinothrips sumatrensis
PARTIAL OVOVIVIPARITY
COMPLETE OVOVIVIPARITY
VIVIPARITY
DENSE AGGREGATION
in masses
Tiarothrips sumatrensis
in masses
Bactridothrips idolomorphus
unfavourable conditions
favourable/isolated condions
Eggs in irregular mass of 10–110
AGGREGATED
NON AGGREGATED
bark of Eucalyptus sp. infested with Cytospora sp.
dry twigs infested with Rhytidhysterium rufula
Favourable conditions
unfavourable conditions
Priesneriana kabandha

Fig. 1.

ovoviviparity are also adaptations to shorten the life-cycle, enabling the young ones to complete development before the food disappears (Ananthakrishnan *et al.* 1983).

Of particular interest is the adaptative specialization of some of the phytophagous species taking to a cecidogenous habitat producing malformation or galls. It is well known that the initiation and exploitation of plant tissues leading to the formation of galls is a highly developed form of phytophagy. Different kinds of tissue reorganization result when a gall is formed and the basic strategies for successful survival within the gall environment is hyperplasy and hypertrophy and incidental cell realignment so as to establish the gall form. Transformation of such differentiated tissues into actively dividing meristematic tissues as well as the organization of a nutritive zone in the form of highly specialised patches of cells are further adaptations for survival by gall thrips as of other gall insects. The occurrence of polymorphism is equally typical of gall thrips and such polymorphism induces intraspecific competition (interspecific when more than one species is involved), which considerably influences the patterns of mating and fecundity. Rarely as in *Thilakothrips babuli* forming the leaf rosette galls in *Acacia leucophloea,* there is the ability to switch over to the formation of the inflorescence gall from the leaf rosette gall, with accompanying changes in the duration of the life cycles, being shorter in the inflorescence galls and longer in the leaf rosette galls. Gall insect-host plant association therefore exemplifies an advanced level of 'trophic strategy' (Ananthakrishnan 1984).

Studies involving the role of larvae, adult males, and adult females on gall development and induced morphological variations by maintaining a constant population of each of them on the leaves of host plants of varying ages reveal the efficiency of larvae and adult females towards a faster development of the galls together with significant morphological and internal structural variations involving maximum tissue responses, indicating the significance of the role of the cumulative feeding effect of larvae and adult females in the galling phenomena (Ananthakrishnan 1981). Adult females when compared to the males spend more energy by laying eggs for the build-up of populations resulting in continuous feeding to compensate for the energy lost. The adult males which spend less energy, exhibit poor feeding responses. Larvae being voracious feeders also contribute much to the galling phenomena. Another interesting feature is the change of feeding sites by adult thrips to the lower epidermis due to competition among individuals under high population densities. The host plant is a part of the essential framework within which intraspecific competition between the insects must take place to limit the number when it rises above a critical density, while at the same time the growing insect population makes increased demands on the plant, thereby affecting its growth and quality. As disclosed by van Emden and Way (1973), that limitation through complete utilization of available food supply may occur more commonly when the insect is severely restricted to a particular part of the plant or by a 'resistance' mechanism to a particular growth stage, appears significant in the galling phenomena.

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BREEDING BIOLOGY OF SOME INDIAN BATS — A REVIEW

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(*With eleven text-figures*)

INTRODUCTION

A reviews of earlier literature on the reproduction of bats have been made by Baker and Baker (1936), Baker and Bird (1936), Gopalakrishna (1947) and more recently by Gustafson (1979), Krutzsch (1979), Oxberry (1979), Jerrett (1979) and Racey (1979) on certain aspects of the breeding biology of the bats. The present article highlights the reproductive patterns of some Indian bats. However, references to the work on bats in other parts of the world will be made where pertinent.

The first discovery by Pagenstecher (1859) in Germany of the presence of large numbers of live spermatozoa in the genital tract of the females of *Pipistrellus pipistrellus* throughout winter months, even though ovulation had not occurred in these specimens, drew the attention of several workers in Europe to this curious fact. Several subsequent workers (Eimer 1879, Benecke 1879, Fries 1879, Rollinat and Trouessart 1895a, b, c, 1896, 1897; Grosser 1903, Courrier 1924, 1927; Rendez 1929 and Matthews 1937) confirmed that copulation in several European vespertilionid and rhinolophid bats occurs during autumn and the spermatozoa remain alive and viable throughout winter and fertilise the ova released during the following spring. Such a phenomenon was also reported to occur in several bats inhabiting cold and temperate regions (Gaisler 1965, Dwyer 1966, Al Rabaake 1968, Kitchener 1975, Hiraiwa and Uchida 1955). The crucial experiment of keeping inseminated females isolated from the males throughout winter were carried out by Gates (1936), Folk (1940), Wimsatt (1942, 1944), Hiraiwa and Uchida (1956) and Racey (1973, 1975) who affirmed that in several European, American and Japanese bats the spermatozoa inseminated during autumn remain viable and fertilise the ovum released during the following spring. A few other workers (Guthrie 1933, Caffier and Kolbow 1934, Miller 1936, 1937, 1939; Pearson *et al.* 1952), however, indicated that, although copulation in the bats inhabiting temperate regions occurs during autumn, subsequent copulations also occur during winter and spring either as a general rule or in those females which had missed or had unsuccessful copulation during autumn.

In spite of the fact that the seasons are not very well demarcated in the tropical regions, most bats inhabiting these regions have a strict reproductive periodicity (Baker and Baker 1936, Baker and Bird 1936, Gopalakrishna 1947, 1948, 1949; Brosset 1962a, b, c, 1963; Gopalakrishna *et al.* 1975, Gopalakrishna and Choudhari 1977, Gopalakrishna and Rao 1977, Gopalakrishna and Madhavan 1978, Gopalakrishna *et al.* 1979, Gopalakrishna and Bhatia 1983, Gopalakrishna *et al.* 1985, Ramaswamy

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1961, Kumar 1965, Madhavan 1971, 1978, 1981; Sapkal and Khamare 1984, Sapkal and Bhandarkar 1984, Sapkal and Deshmukh 1985, Kashyap 1980), and undergo copulation which is immediately followed by fertilisation and pregnancy. Storage of inseminated spermatozoa, and fertilisation by the stored spermatozoa of the ova released several weeks later, have been reported only in a few tropical species (Gopalakrishna and Madhavan 1971, 1978; Medway 1972, 1973; Racey *et al.* 1975, Krishna and Dominic 1978).

The foregoing account presents only two main patterns of reproduction in bats, namely, where there is no sexual synchrony between the male and the female (mostly in species inhabiting cold and temperate regions) and where the sexual activity is synchronous in the two sexes (mostly in tropical species).

REPRODUCTIVE PATTERNS IN THE FEMALE

Anatomy of the female genitalia

Although in all Indian bats the uterus is constructed on a bicornuate plan, there are interesting variations in the details of the internal anatomy. Ashfaque and Tungare (1960) studied the anatomy of the female genitalia of a few bats and indicated that they exhibited an evolutionary pattern from a condition, where the two sides are nearly completely separate, to a condition where the partial atrophy of one of the uterine cornua gives the genitalia a nearly unicornuate appearance. In *Pteropus giganteus giganteus* the vagina is septate for more than three fourths of its length and the two uterine cornua open into the vaginal canal of the respective side. Thus, the two sides of the genitalia in this animal are nearly completely separated — almost recalling the condition occurring in Metatheria. In *Cynopterus sphinx gangeticus* the septum in the vagina extends to about half the cranial length of the vagina. In *Rousettus leschenaulti* (Choudhari 1968, Karim 1975) the lumina of the two uterine cornua remain separate and open by independent canals at the tip of a bulbous cervix which projects for a short distance into the vagina. In *Taphozous longimanus* (Gopalakrishna *et al.* 1979), whereas the two cervical canals open independantly at the tip of an elongated cervix in the nonparous females, the tip of the cervix seems to break away during the first parturition. Hence, in adult females the two cervical canals, although independent, join just before opening into the vagina at the tip of the cervix. In most of the bats (Gopalakrishna and Karim 1980), the two uterine cornua become confluent and open into to cervix by a common opening. In *Tadarida plicata plicata* (Pendharkar 1981) and *Miniopterus schreibersii fuliginosus* (Chari 1980, Gopalakrishna and Chari 1984) the left uterine cornu is markedly smaller than the right.

Physiology of the female genitalia

Most vespertilionids are polytocous and the two uterine cornua are physiologically symmetrical and the two sides of the genitalia are functional during every breeding cycle (Gopalakrishna 1947, Madhavan 1971, 1978, 1981). Bats belonging to other families are usually monotocous and exhibit varying degrees of physiological dominance. In *Taphozous longimanus* (Gopalakrishna 1954, 1955), *Rousettus leschenaulti* (Gopalakrishna 1964, 1969; Gopalakrishna and Choudhari 1977) and *Cynopterus sphinx* (Sandhu 1984), while the two sides of the genitalia have equal physiological potentiality, only one side functions during each cycle, and there is a physiological alternation of the two sides of the female genitalia in successive cycles. Among hipposiderid bats (Madhavan *et al.* 1977, Gopalakrishna and Bhatia 1983, Sapkal and Bhandarkar 1984) the left side of the genitalia exhibits a distinct physiological dominance over the right side — about 65 to 75% of ovulation and pregnancy occurring on the left side. In *Megaderma lyra lyra* (Ramakrishna 1951, Ramaswamy 1961, Gopalakrishna *et al.* 1979) the left side of the genitalia is completely dominant, and ovulation and pregnancy in every cycle occur only on the left side, the right ovary not even producing mature follicles. Two cases of twinning have been reported in this bat, but only in one case it was proved conclusively that both the cornua had a foetus each (Ramaswami and Kumar 1963); in the case of the other twin embryos (Gopalakrishna *et al.* 1974) there was no mention regarding the location of the two twin embryos. In both cases the authors could not identify the ovary, which had ovulated, due to the absence of the corpus luteum in the ovaries since the corpus luteum in this bat disappears at an early stage of pregnancy (Gopalakrishna and Badwaik — in press). In contrast to this condition, the right side of the genitalia is completely dominant in *Rhinolophus rouxi* (Gopalakrishna and Rao 1977), *Taphozous melanopogon* (Gopalakrishna and Karim 1980, Sapkal and Khamare 1984, Sandhu 1986), *Taphozous kacchensis* (Sapkal and Deshmukh 1985), *Tadarida aegyptiaca* (Kashyap 1980, Sandhu 1986) and *Tadarida plicata plicata* (Pendharkar 1981). In parous females of the two species of *Tadarida* the left uterine cornu is markedly smaller than the right, and the left ovary does not even produce mature follicles. *Miniopterus schreibersii fuliginosus* presents the most extraordinary condition of the female genitalia. In this species, while ovulation as a rule occurs from the left ovary, and fertilization of the ovum and the early development of the embryo take place in the left Fallopian tube, the embryo in the morula stage migrates to the right uterine cornu, where it implants and undergoes further development (Gopalakrishna *et al.* 1979, Gopalakrishna *et al.* 1981, Gopalakrishna *et al.* 1985). The dominance of the right uterus in bearing pregnancy was noticed in *Myotis lucifugus lucifugus*, but ovulation in this species occurred from either ovary with nearly equal frequency (Wimsatt 1979).

BREEDING HABITS

On the basis of the breeding habits the Indian bats can be broadly classified into the following categories:

Annual cycle

The species which have an annual reproductive cycle and breed once a year in a strictly defined breeding season fall into this category. The exact season of reproduction, however, varies among different species. This category can be further recognised into three types depending on the season of onset of breeding activity. It is pertinent to mention here that in Indian conditions the words 'spring', 'autumn' and 'winter' do not have the same significance as in temperate and cold countries because the changes in the different seasons in the tropics are not so marked as those in cold countries. These words are used in the present article broadly to indicate February-April as spring, September-December as autumn-winter and June-August as rainy season.

Spring breeders

These species come to sexual activity, and copulate and undergo ovulation in March-April with pregnancy following immediately. To this category belong *Scotophilus temmincki*

(*S. wroughtoni*) (Gopalakrishna 1947, 1948, 1949) around Bangalore, *Miniopterus schreibersii fuliginosus* (Gopalakrishna *et al.* 1985) at and around Mahabaleshwar, *Taphozous melanopogon* at Chikalda and Narnala (Sapkal and Khamare 1984) and at Burhanpur and Asirgarh (Sandhu 1986) and *Taphozous kacchensis* (Sapkal and Deshmukh 1985) at Agra.

Autumn -- Winter breeders

These come to sexual activity during October-December and experience pregnancy immediately after copulation. To this category belong *Megaderma lyra lyra* at Srirangapattana (Ramakrishna 1951), at Agra (Ramaswamy 1961) and around Nagpur (Gopalakrishna 1950, Gopalakrishna *et al.* 1974), *Rhinolophus rouxi* at Khandala (Gopalakrishna and Rao 1977, Gopalakrishna and Ramakrishna 1977) and at Bangalore and Khandala (Ramakrishna and Rao 1977), *Hipposideros fulvus fulvus* at Nanded (Madhavan *et al.* 1977) and *Hipposideros ater ater* at Nanded (Gopalakrishna and Madhavan 1978).

Rainy season breeders

Those bats, which come to sexual activity in June or early in July and experience pregnancy soon after copulation, come under this category. To this category belong *Tadarida aegyptiaca* at and around Khandwa (Kashyap 1980, Sandhu 1986) and *Tadarida plicata plicata* (Pendharkar 1981).

Pipistrellus ceylonicus chrysothrix at Nanded (Madhavan 1971, Gopalakrishna and Madhavan 1971) experiences estrus and undergoes copulation during the first two weeks of June, but ovulation does not take place until about the second week of July, when the inseminated stored spermatozoa, which remain viable, fertilise the ova and pregnancy follows immediately. A similar phenomenon, but occurring during a different season, obtains in *Scotophilus heathi* at Cochin (Gopalakrishna and Madhavan 1978, Madhavan 1981) in which, while copulation occurs in the middle of November, ovulation and fertilisation do not take place until about the last week of December. During this interval the inseminated spermatozoa are stored in the female genital tract and retain their viability.

Breeding twice in a year with strict sexual periodicity

Some species have a strict reproductive periodicity, but experience two cycles in quick succession. In these species the lactation period of the first cycle overlaps the early pregnancy of the second cycle. Such a situation occurs in *Rousettus leschenaulti* at Aurangabad (Gopalakrishna 1964, Gopalakrishna and Choudhari 1977) and *Cynopterus sphinx* at Bangalore (Ramakrishna 1947) and at Nagpur (Sandhu 1984). In *Rousettus leschenaulti* the two sides of the genitalia function alternately in successive cycles due to the protracted persistence of a large corpus luteum until the beginning of the succeeding pregnancy (Gopalakrishna 1969).

Anomalous breeding habits

There are certain bats, which, although experiencing a strict reproductive periodicity, present a few anomalies. *Rhinolophus rouxi* (Ramakrishna and Rao 1977) presents certain reproductive adaptations to suit the environmental conditions. At and around Bangalore ovulation and fertilisation occur in the last week of November, whereas at Khandala female do not undergo copulation until the middle of December. The gestation period of this bat is 150 ± 8 days. Whereas the early embryonic development of this species is considerably slowed down at Bangalore, there is a delay in the implantation of the blastocyst in the specimens at Khandala. Deliveries at Bangalore occur about four weeks earlier than at Khandala. The authors suggested that this change in the reproductive pattern of the same species at two different localities is an adaptation to bring forth the young ones at the most propitious season.

A situation nearly similar to that of *Rhinolophus rouxi* appears to obtain in *Hipposideros speoris,* which has been studied at Bangalore, Nanded and Chandrapur. Although the female breeds only once a year, the time of breeding is delayed progressively at higher latitudes. At Bangalore the females come to estrus and copulate late in October and conceive immediately. At Chandrapur, although the specimens undergo copulation in the first week of December and the spermatozoa remain in the female genital tract during the following weeks, ovulation does not occur until the last week of December or early in January. Fertilisation and conception occur at this time in most females in the colony and deliveries occur after a gestation of 135 ± 5 days. However, some females in the colony come to heat early in March and deliver their young in the last week of July. It is not known if inseminated spermatozoa are stored and fertilise the ova released several weeks later in these specimens, which copulate early in December and conceive during the last week of December. Some more details about this species will be described while dealing with the male sex-cycle.

In *Hipposideros lankadiva* at Balharsha (Sankal and Bhandarkar 1984) copulation occurs during the latter half of August and is immediately followed by ovulation and fertilisation. However, the early development of the embryo until implantation of the blastocyst is unusually slow — nearly two months. Even the post-implantation development is also considerably retarded until the limb-bud stage of development. Consequently, the gestation of this bat lasts for about 260 to 270 days.

Continuous breeders

A few Indian bats do not have a strictly defined reproductive season. In *Taphozous longimanus* at Nagpur (Gopalakrishna 1954, 1955), *Pipistrellus mimus mimus* at Nanded (Gopalakrishna *et al.* 1975) and *Pipistrellus dormeri* at Nanded (Madhavan 1978) there is a quick succession of pregnancies and the lactation period of one cycle overlaps the early gestation of the succeeding cycle. More than two litters are produced during each year in these species.

REPRODUCTIVE PATTERNS IN THE MALE

This is the first report on the male reproductive habits of most of the Indian bats described here. Hence, a brief description of the material and methods are given below. The specimens for the present study were collected from different localities in India at least for two successive years such that every month is represented by one collection or more. The specimens were collected from their natural roosts, killed by chloroform, and the male reproductive organs and accessory reproductive structures were fixed in various fixatives such as neutral formalin, Bouin's, Rossman's, Zenker's or Carnoy's fixative. The right testis of all the specimens was weighed by a Mettler balance. The tissues were stored in 70% ethanol after fixation for 24 hours and processed by the usual procedure, and paraffin embedded tissues were sectioned serially at 6 to 10 μ thickness. For the present work the tissues were stained by Ehrlich's or Harris' haematoxylin and counterstained by eosin, dehydrat-

TABLE 1

DETAILS OF COLLECTION RECORD OF MALE SPECIMENS OF DIFFERENT SPECIES OF BATS

Month	*Rousettus leschenaulti* J A	*Megaderma lyra lyra* J A	*Rhinolophus rouxi* J A	*Hipposideros fulvus fulvus* J A	*Hipposideros speoris* J A	*Hipposideros ater ater* J A	*Pipistrellus ceylonicus chrysothrix* J A	*Scotophilus heathi* J A	*Miniopterus schreibersii fuliginosus* J A
January	12+61(6)	0+10(2)	14+10(8)	1+15(7)	8+13(9)	0+11(6)	0+24(9)	0+15(10)	4+12(3)
February	19+43(4)	0+9(2)	6+25(7)	0+5(4)	1+22(5)	0+23(5)	0+10(5)	0+19(10)	29+85(11)
March	25+43(6)	0+2(1)	3+15(4)	1+5(6)	0+4(3)	0+24(7)	0+23(7)	0+24(15)	41+116(11)
April	57+52(9)	0+5(1)	3+12(3)	4+4(3)	0+10(10)	0+1(1)	0+20(5)	21+13(26)	20+62(5)
May	16+30(7)	2+2(1)	0+12(3)	35+16(6)	24+23(8)	0+8(4)	0+36(12)	41+12(17)	21+62(7)
June	23+15(5)	8+9(2)	2+18(2)	5+18(4)	21+12(5)	0+12(3)	0+42(14)	2+15(8)	19+49(6)
July	10+9(3)	7+5(2)	2+20(2)	1+9(2)	15+14(5)	13+3(1)	0+56(16)	6+10(7)	23+24(3)
August	4+13(3)	5+4(2)	0+14(3)	1+11(4)	8+16(3)	3+2(1)	0+29(15)	6+6(9)	48+52(6)
September	7+22(5)	7+16(2)	2+8(2)	0+10(4)	9+19(4)	4+2(1)	73+12(15)	15+8(11)	29+58(4)
October	1+8(2)	3+7(1)	1+3(2)	15+17(5)	9+6(3)	0+9(1)	23+19(10)	8+15(14)	47+102(3)
November	23+45(8)	3+8(1)	3+6(2)	7+19(5)	7+27(8)	0+9(2)	0+31(9)	0+39(12)	17+42(5)
December	24+46(6)	3+11(2)	3+7(1)	4+8(6)	14+27(9)	0+10(4)	0+22(7)	0+76(25)	11+42(5)

J: Juveniles; A: Adults. (Figures in brackets represent the number of collections during the month).

ed by graded ethanol, cleared in xylol and mounted DPX or Canada balsam. Table 1 gives the details about the collection record of the males of some species studied here. The reports on other species are based on the collection record of other workers in this laboratory. The details of the breeding activity of the males of some of the species described here are based on the descriptions by other workers.

The male genitalia

One of the conspicuous features of the structure of the male genital organs of the bats is the occurrence of various kinds of anatomical adaptations of the external genital organs for effective coitus. Most species hang freely up-side-down and coitus is invariably *per dorsum.* In this posture intromission overcoming a large interfemoral membrane, and remaining *in coitu* until ejaculation, pose mechanical problems to these animals. The most common adaptation is the presence of numerous backwardly directed spines on the glans penis, and these help in anchoring the penis to the vaginal mucous membrane while in coitus. This is prominently noticed in *Pteropus giganteus giganteus* (Murthy and Vamburkar 1978), *Rousettus leschenaulti* (Gopalakrishna and Murthy 1976), *Cynopterus sphinx* (Vamburkar 1958) and, to a lesser extent in *Megaderma lyra lyra, Hipposideros fulvus fulvus* and *Pipistrellus ceylonicus chrysothrix* (Murthy 1971). In these latter three species the presence of an os penis is an adaptation to provide an additional stiffness to the erect penis for effective intromission. In *Taphozous longimanus* (Murthy 1969) there are, in addition to the presence of numerous rows of backwardly directed sharp spines on the glans penis and the presence of an os penis, two prominent accessory corpora cavernosa, which have the same function as the bulbus glandis in the dog. Evidently, all these adaptations are to prevent premature withdrawal of the penis during coitus.

Breeding habits

Even the brief review on the female reproductive habits of Indian bats made earlier in this article has revealed that there are considerable differences in the season and the pattern of reproductive behaviour among the different species. These studies have also shown that different species inhabiting the same locality may have different reproductive behaviour and the same species in different parts of India exhibit some differences in the reproductive habits (Ramakrishna and Rao 1977).

Among the more than a hundred species of bats included in nine families available in India details of the sexual cycle in the male have been reported so far only in one species, *Scotophilus temmincki* (*S. wroughtoni*) (Gopalakrishna 1948, 1949). It is normally expected that there may be interesting reproductive strategies in the males also to match the variations in the female.

Generally, most Indian bats, which have a sharply defined breeding season, and in which copulation is immediately followed by the fertilisation of the ovum and pregnancy. The male also has a parallel sexual rhythm, which is synchronous with that of the female. The testis comes to activity and vigorous spermatogenesis occurs when the female comes to estrus. The weight of the testis increases considerably, there is a spurt of spermatogenetic activity and there is a pronounced increase in the number, size and secretory activity of the Leydig cells. Concomitantly, the accessory organs also exhibit secretory activity. In the bats, which breed round the year, spermatogenetic activity and the activity of the accessory glands remain at a high peak throughout the year.

The present studies have been undertaken with a view to finding out not only the sexual activity of the males of some Indian species, but also to finding out how these activities are related to the sexual cycles in the females. For the present study the species have been so chosen and grouped together as to represent different categories such as (1) different species from the same locality, (2) same species from different parts of India, and (3) some species randomly chosen for study. In the first group are included (a) *Rousettus leschenaulti* and *Megaderma lyra lyra* from Aurangabad, *Rousettus leschenaulti* and *Miniopterus schreibersii fuliginosus* from Mahabaleshwar in western ghats, *Cynopterus sphinx* and *Taphozous* at and around Nagpur, (b) *Pipistrellus ceylonicus chrysothrix, Pipistrellus mimus mimus, Pipistrellus dormeri* — all collected at and around Nanded, (c) *Taphozous melanopogon* and *Rhinopoma microphyllum* from the same composite colony at Burhanpur, (d) *Hipposideros fulvus fulvus* and *Hipposideros ater ater* from Nanded and surrounding areas, (e) *Taphozous kacchensis* and *Megaderma lyra lyra* at and around Agra. The second category includes (a) *Megaderma lyra lyra* from Srirangapattana, Nagpur and Agra, (b) *Rhinolophus rouxi* from Bangalore and Khandala, (c) *Hipposideros speoris* from Bangalore, Nanded and Chandrapur. To the third category belongs *Scotophilus heathi* from Cochin. As mentioned earlier, the reproductive cycles of the female have been studied in all the species mentioned above.

Different species from the same locality

(a) *Rousettus leschenaulti* and *Megaderma lyra lyra* from Aurangabad:

All the specimens were collected at and around Bibi-Ka-Makbara at Aurangabad. The two species live in different colonies in two different underground tunnels. *Rousettus* colony consists of about 5,000 specimens and the colony of *Megaderma* varies in number between about 500 to 800 in different seasons of the year. The specimens were collected from January 1963 to December 1964.

Figure 1 is a scatter diagram of the weight of the right testis of the specimens of *Rousettus* plotted against the date of collection of the specimens. From the graph it is evident that the testis weight of the adult animals has a double peak in the year corresponding to the two pregnancy cycles in the female. *Megaderma* has a single peak corresponding to a single cycle in the year (loc. cit.). In both the species the peak weight of the testis corresponds to the season of copulation. Histological examination of the testis reveals that the peaks of testis weight closely correspond to the height of spermatogenetic activity. In both the species the accessory reproductive organs also exhibit their peak activity when the testis is active as revealed

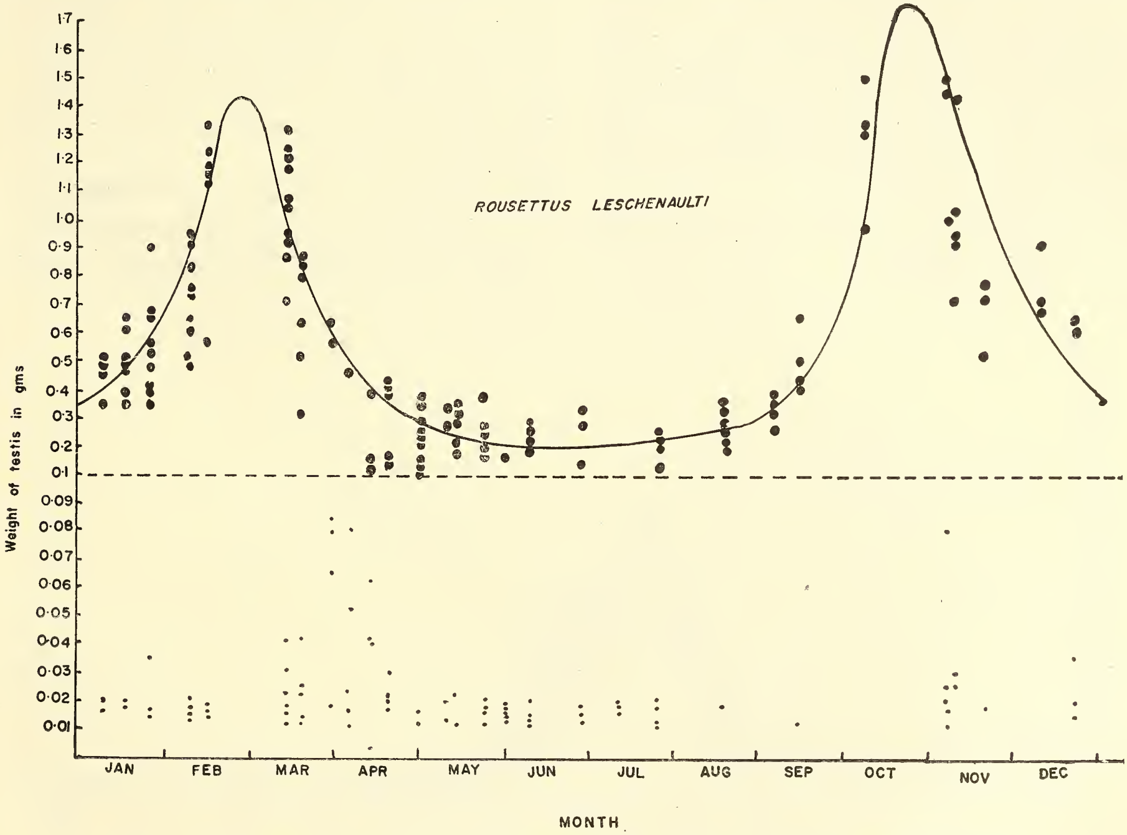

Fig. 1. Scatter diagram in which the weight of the testis is plotted against the dates of collection of *Rousettus leschenaulti.* Note the two peaks of the curve indicating two peaks of testicular activity.

(In all the 11 figures the larger dots represent adult animals and the smaller dots represent juvenile specimens. The dotted lines parallel to the two axes indicate the lowest weight of testis or the body (as the case may be) at sexual maturity.

by the increase in their size and changes in their histological structure.

(b) *Rousettus leschenaulti* and *Miniopterus schreibersii* at Mahabaleshwar:

The two species inhabit the Robbers' cave throughout the year. Whereas the weight and the histology of the testis, and the histology of the accessory reproductive organs of *Rousettus leschenaulti*, exhibit the same pattern as in the specimens at Aurangabad, *Miniopterus* presents a very different pattern of sexual activity. The testis in the adult males reach peak values in January and February when copulation occurs, after which the testis regresses and remains inactive during the rest of the year. The activity of the accessory reproductive organs closely parallel the activity of the testis in both species.

(c) *Cynopterus sphinx* and *Taphozous longimanus* at Nagpur:

Cynopterus has two peak periods of spermatogenetic activity when the weight of the testis of adult animals also reaches high peaks (Sandhu and Gopalakrishna 1984). The first peak is in September-October and the second in February-March. The two peaks correspond to the two pregnancy cycles of the female except that the highest peak of spermatogenetic activity occurs about two weeks before the females come to estrus. During this period the cauda epididymis is engorged with spermatozoa and is markedly enlarged. *Taphozous longimanus* in the same locality, being a continuous breeder, does not exhibit changes in the weight of the adult testis during the year. The testis of the adult animals is active throughout the year.

(d) *Pipistrellus ceylonicus chrysothrix, P. minus minus* and *P. dormeri* at Nanded:

These three species have different breeding

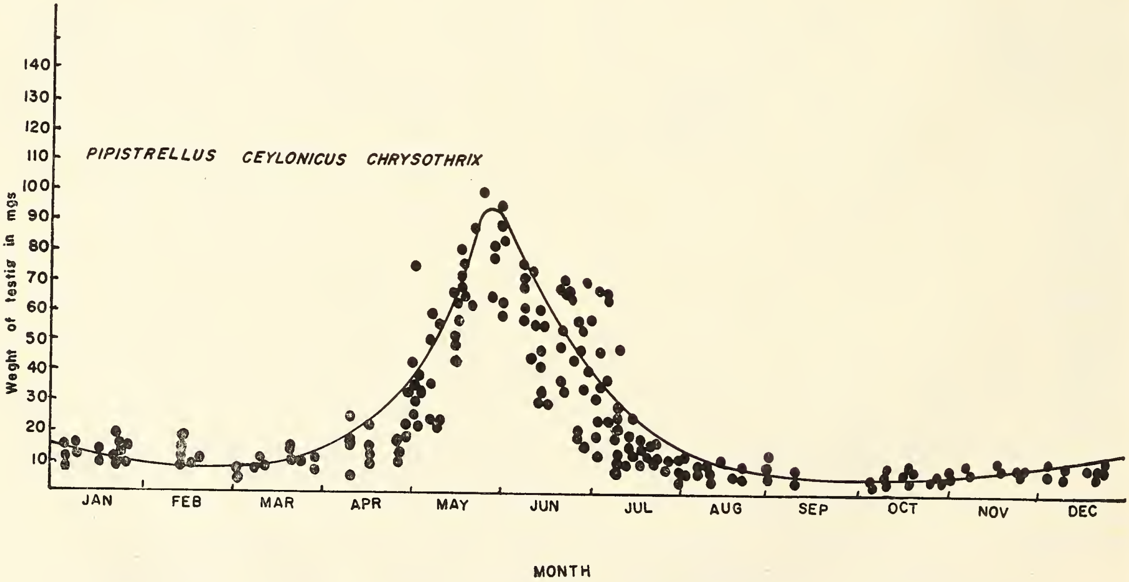

Fig. 2. Scatter diagram of the adult testis weight plotted against the dates of collection of *Pipistrellus ceylonicus chrysothrix*. Note the single peak of testis weight during the latter part of May and June.

patterns (Madhavan 1971, Gopalakrishna *et al.* 1975, Madhavan 1979). In *P. ceylonicus chrysothrix* the testis comes to activity in May and reaches its peak in June which is the season of copulation (fig. 2). The regression of the testis in this animal is rapid and there is complete cessation of spermatogenesis after the first week of July. The testis has low weight until the following May. On the other hand, in the other two species the adult testis exhibits spermatogenesis throughout the year.

(e) *Taphozous melanopogon* and *Rhinopoma microphyllum* from Burhanpur:

Both these species occur in one large composite colony of 5,000 to 6,000 specimens in the rooms and dungeons of a dilapidated old fort at Burhanpur. Both species are found throughout the year, but the number of specimens become reduced during certain months of the year (Gopalakrishna 1986). Copulation in *Taphozous* occurs during the latter half of January and the females conceive immediately and deliver the young in May. The weight of the adult testis starts increasing from the middle of December and reaches peak values during January. The weight of the testis decreases rapidly after the second week of February and remains at low levels during the rest of the year. Spermatogenetic activity and the activity of the accessory reproductive organs parallel the changes in the weight of the testis. In *Rhinopoma* the testis weight commences to increase in January and reaches peak values in February after which there is a sudden fall in the weight of the testis accompanied by the regression of the testis. However, the spermatozoa are stored in the epididymis. The accessory reproductive organs come to activity late in February and are most active during the first half of March. Copulation takes place during the first half of March and the females conceive immediately. In this species, therefore, the activity of the testis and the estrus in the female do not coincide, the testis

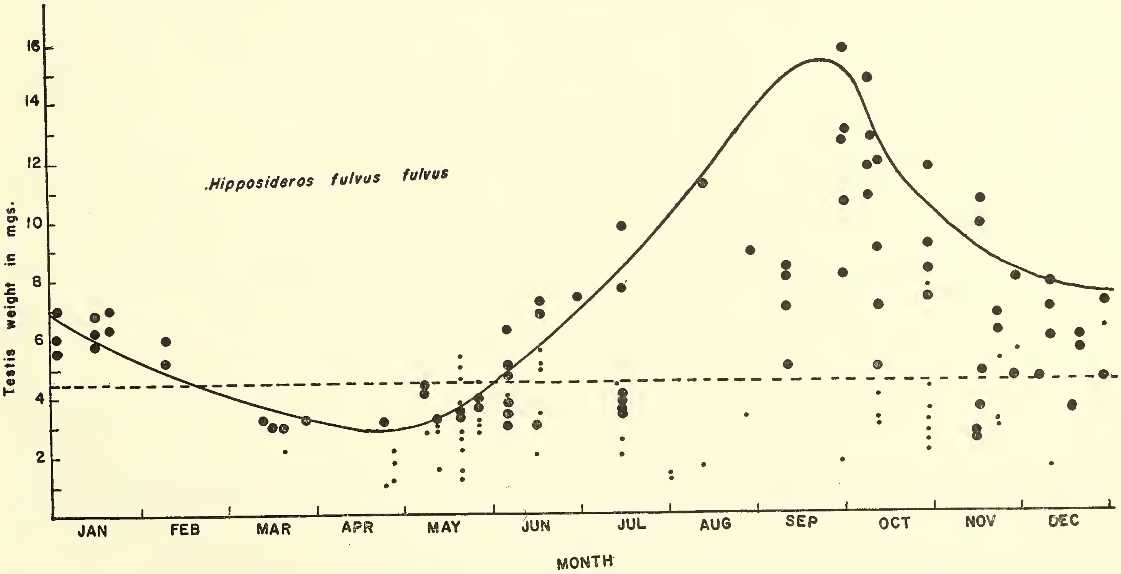

Fig. 3. Scatter diagram of testis weight plotted against dates of collection of *Hipposideros fulvus fulvus.* Note the single peak of testicular activity as indicated by the curve.

coming to activity more than two months prior to the time when the females come to estrus. Although, the testis undergoes regression, the spermatozoa stored in the epididymis remain viable and fertilise the ova released in March. The maintenance of the activity of the accessory organs in this bat is evidently under the control of factors other than those which initiate and maintain spermatogenesis.

(f) *Hipposideros fulvus fulvus,* and *H. ater ater* from Nanded:

The specimens of the above species were obtained from old houses and wells at and around Nanded. In both the species there is a synchrony of the reproductive activity of the two sexes. The testis increases in weight rapidly during October and November accompanied by an increase in the activity of the accessory organs. Copulation occurs late in November and conception follows immediately. Figure 3 gives the changes in the weight of the testis during different months of the year in *H. fulvus fulvus.* The pattern of changes in the weight of the testis of *H. ater ater* is similar to that in *H. fulvus fulvus.*

(g) *Taphozous kacchensis* and *Megaderma lyra lyra* at Agra:

There are marked differences in the repro-

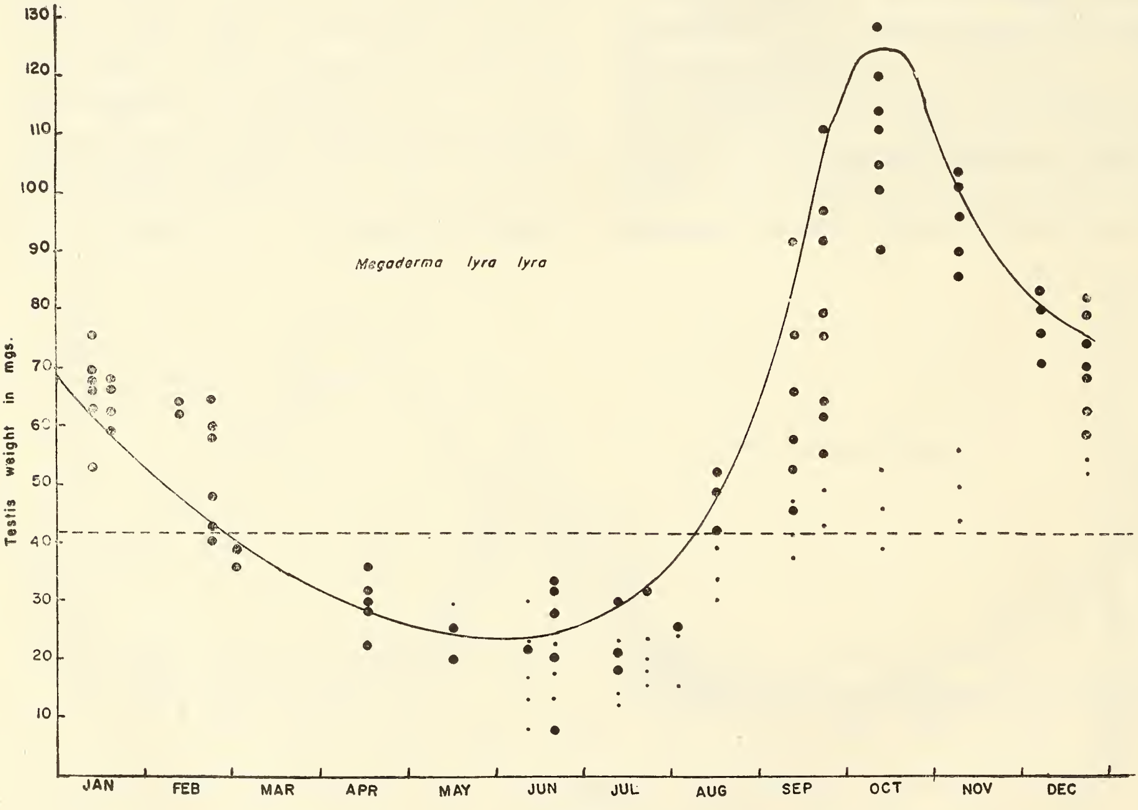

Fig. 4. Scatter diagram of testis weight plotted against dates of collection of *Megaderma lyra lyra* at Srirangapattana. The curve indicates the changes in the weight of the testis of adult animals during the year.

ductive behaviour of the two bats. In *T. kacchensis* the testis and the accessory reproductive organs reach peak activity in March (Deshmukh 1984). In *Megaderma lyra lyra* the testis is most active in the last week of November and the first week of December. The breeding activity is synchronous in both sexes in both the species.

Same species from different regions

Under this category are studied three species: *Megaderma lyra lyra, Rhinolophus rouxi* and *Hipposideros speoris*

(a) **Megaderma lyra lyra**

The breeding behaviour of this species has been studied at Srirangapattana, Nagpur and Agra. In all the regions this species is an 'autumn-winter' breeder (October-December) (fig. 4). The date of copulation, however, advances progressively from higher to lower latitudes. While this species exhibits high peak of testis activity in October at Srirangapattana, the testis reaches peak state of activity in the middle of November at Nagpur and during the last week of November and the first week of December at Agra. The sexual activity is synchronous in both sexes in all the regions.

(b) **Rhinolophus rouxi**

The breeding habits of this animal have been studied at and near Bangalore and at Khandala. The peculiarities of the female sex-cycle in this animal have already been reported (Gopalakrishna and Ramakrishna 1977, Ramakrishna and Rao 1977, Gopalakrishna and Rao 1977). The males at and around Bangalore exhibit

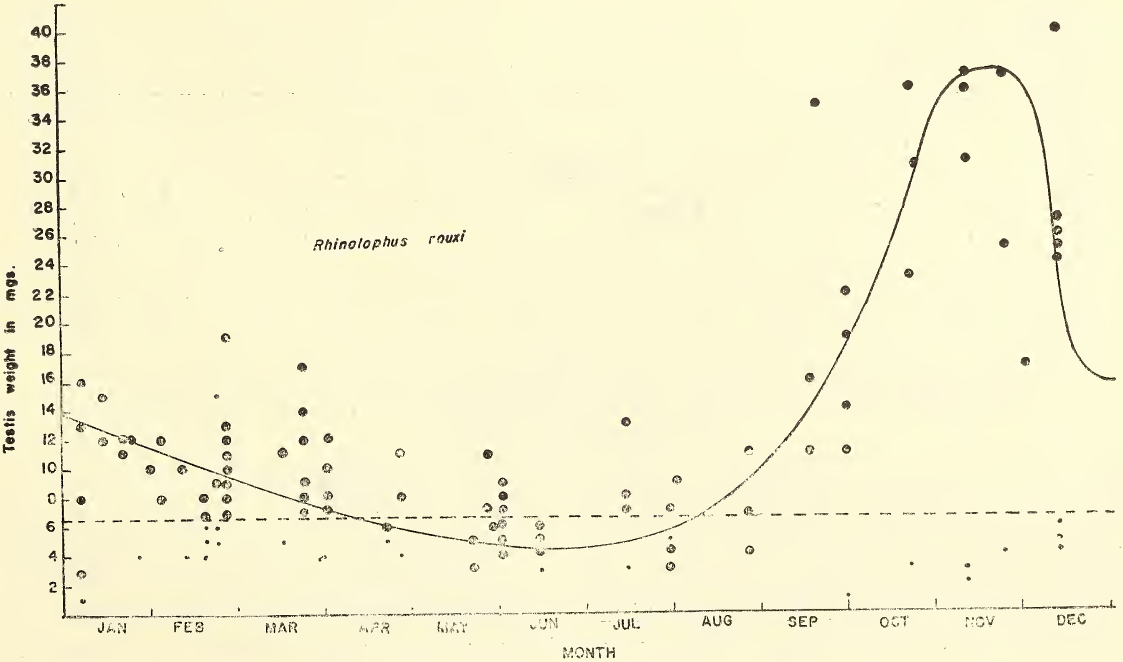

Fig. 5. Scatter diagram of testis weight plotted against the dates of collection of *Rhinolophus rouxi* at Khandala. Note the single peak of testis activity.

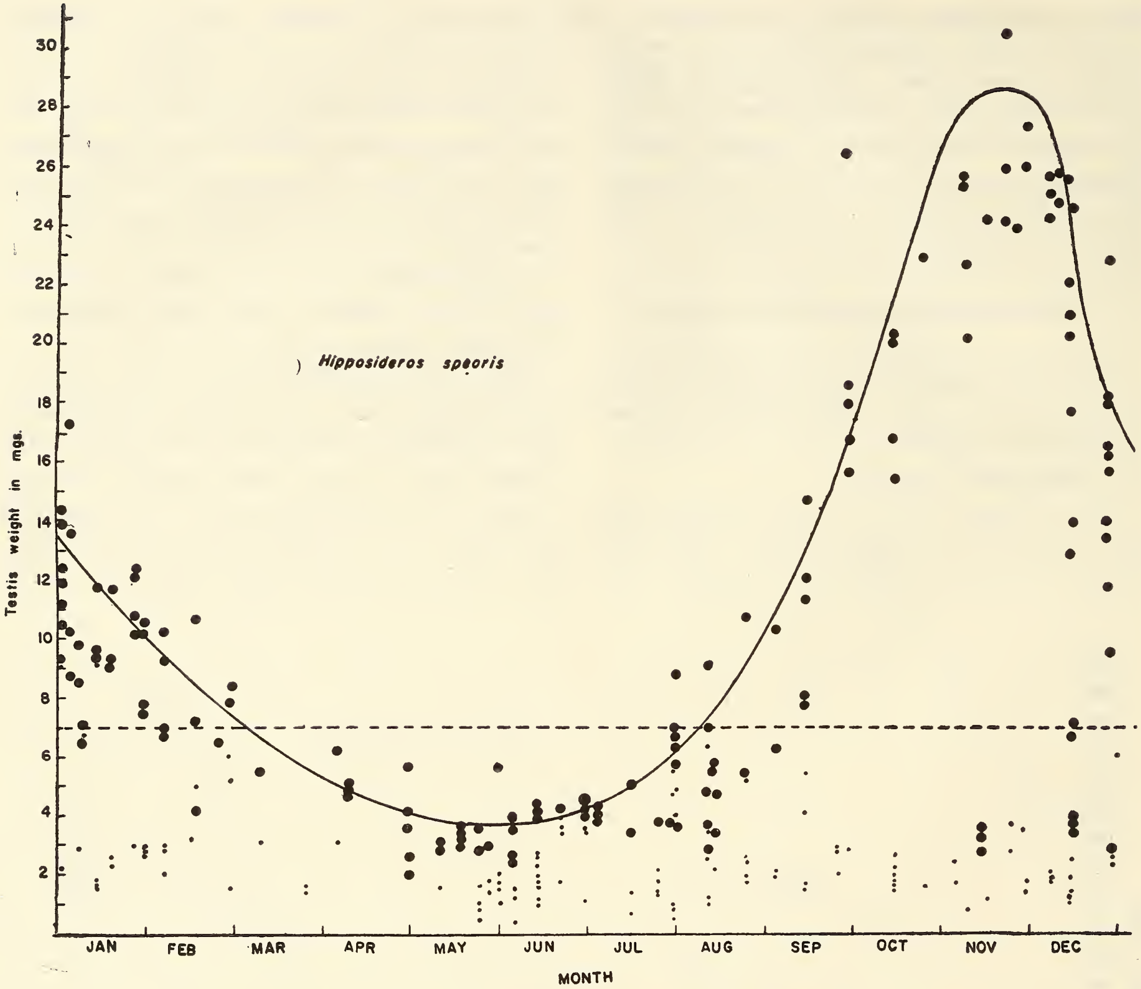

Fig. 6. Scatter diagram of testis weight plotted against the dates of collection of *Hipposideros speoris* at and around Bangalore. Note the single peak of testis activity as indicated by the curve.

peak spermatogenetic activity late in October and early in November, whereas at Khandala the peak period of testis activity occurs in the middle of December. During the rest of the year the testis is regressed. The activity of the accessory organs is synchronous with that of the testis in both the localities. The changes in the weight of the testis during the different months are indicated in figure 5.

(c) **Hipposideros speoris**

This species has been examined at and around Bangalore, Nanded and Chandrapur. It exhibits marked variations in the male reproductive activity in the three regions. At Bangalore the testis commences to increase in weight from the first week of September and reaches peak values during October and until the last week of November, after which there is a sudden fall in the weight of the testis (fig. 6). The testis is regressed during the rest of the year. Spermatogenetic activity closely parallels the activity of the accessory organs. At Nanded the males come to sexual activity in the middle of December and active spermatogenesis continues untill the end of January. Copulation occurs between the last week of December and the first week of January and pregnancy commences immediately. The testis and accessory structures are regressed during the rest of the year. The sexual habits of this animal at Chandrapur (Gopalakrishna and Bhatia 1980, 1983) appears to be markedly different from those in the other two regions. The testis commences increasing in weight from the middle of November and reaches peak values during the middle of January and early in February. The testis regresses after the middle of February, but the

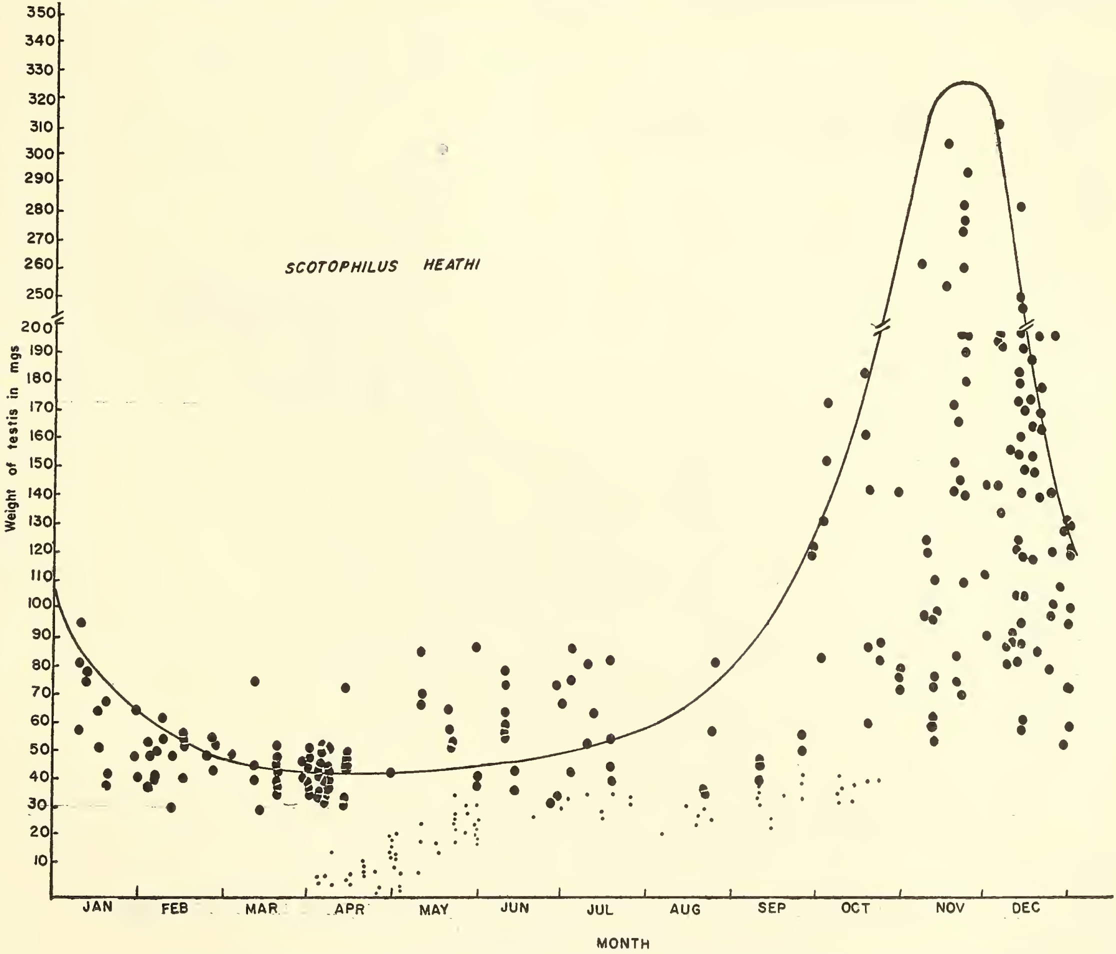

Fig. 7. Scatter diagram of the testis weight plotted against the dates of collection of *Scotophilus heathi* at Cochin. Note the single peak of testis activity during October-November.

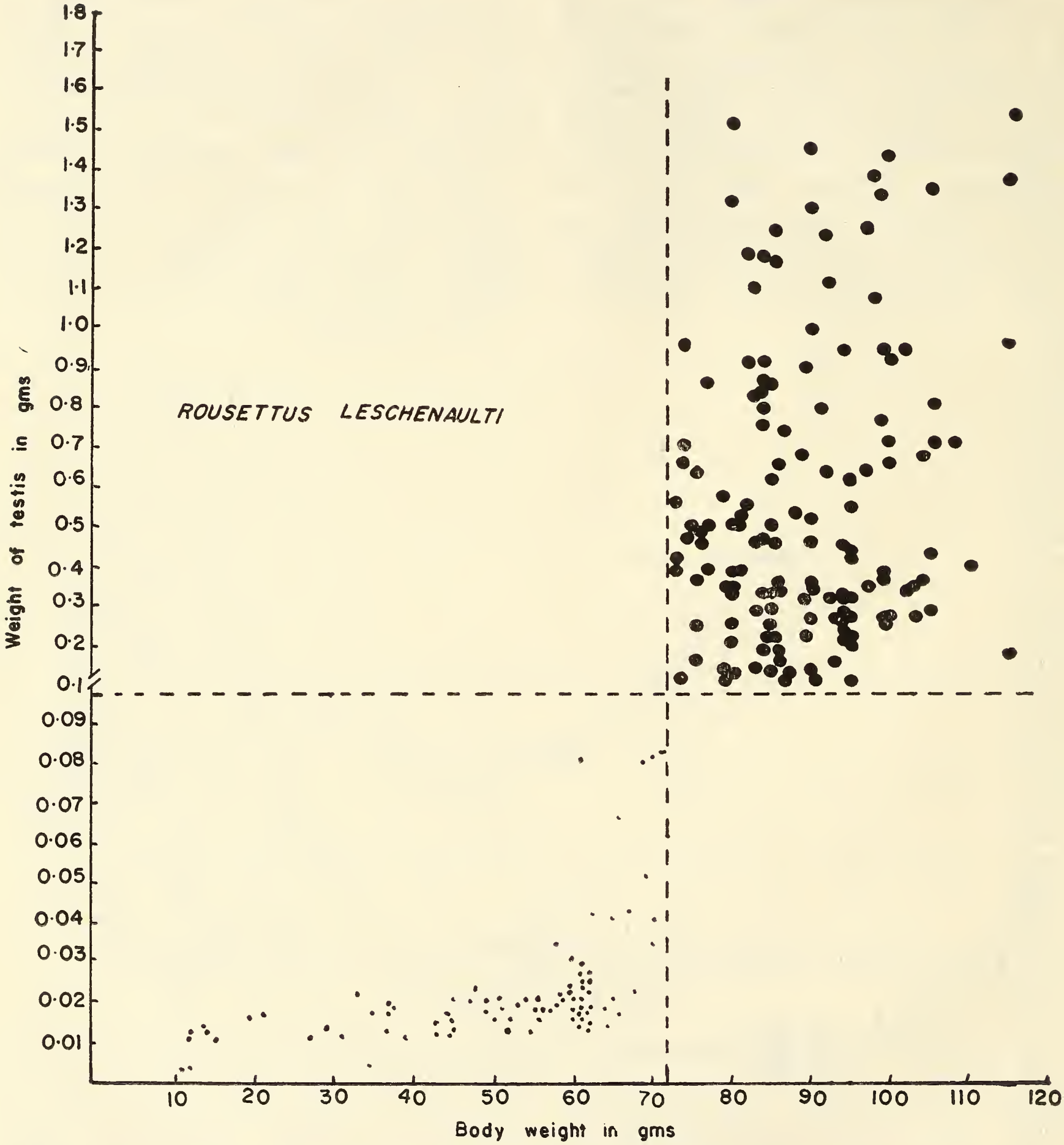

Fig. 8. Scatter diagram in which the testis weight is plotted against the body weight in *Rousettus leschenaulti.*

cauda epididymis is markedly enlarged and is full of spermatozoa. The accessory reproductive organs remain in full activity until the middle of March, and copulation in some of the females in the colony takes place in March with deliveries occurring in July-August. Some of the specimens in the colony appear to have a breeding pattern similar to that in *Rhinopoma microphyllum* at Burhanpur. Perhaps, the late breeders of *Hipposideros speoris* at Chandrapur either missed copulation earlier or had not attained sexual maturity until March. Since this species appears to present such wide variations in its breeding habits at different localities it would be interesting to study in detail the reproductive biology of this species from other parts of India also.

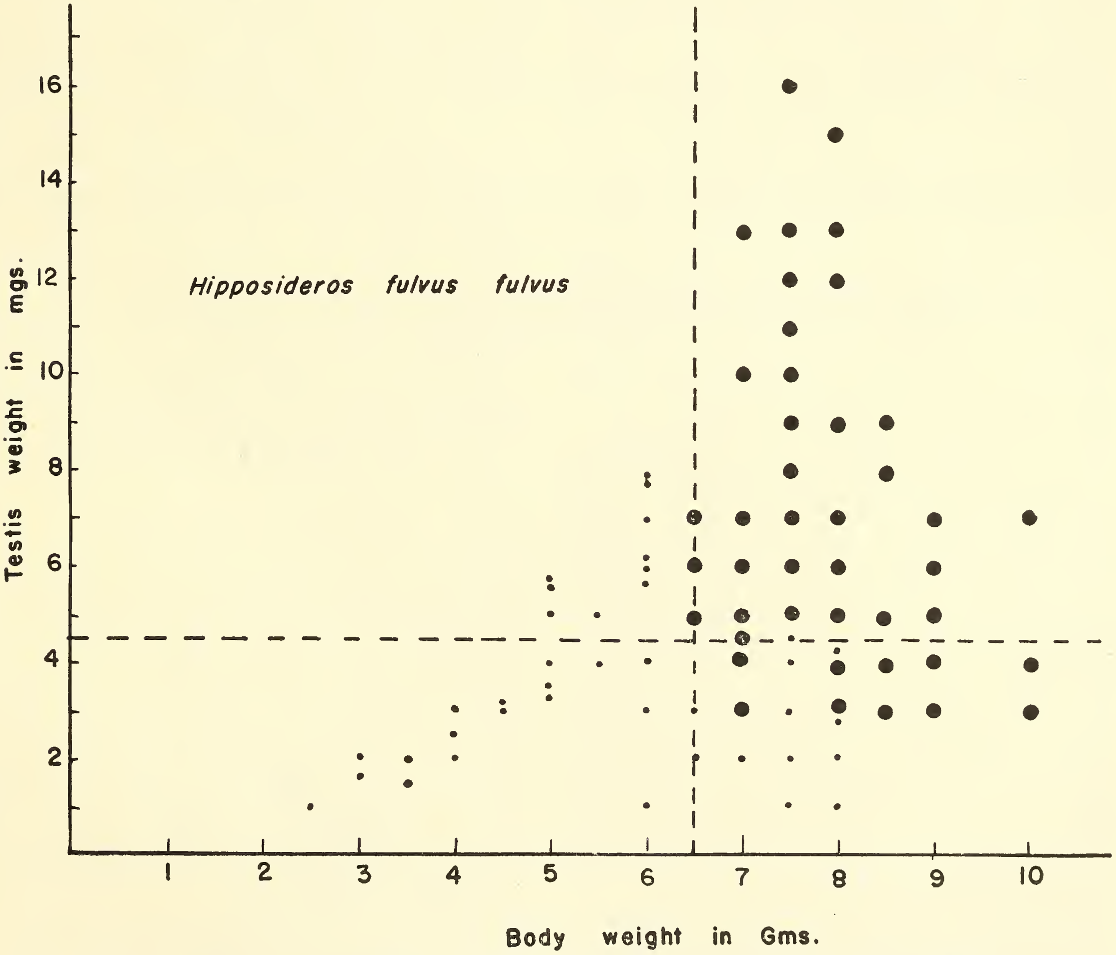

Fig. 9. Scatter diagram in which the testis weight is plotted against the body weight in *Hipposideros fulvus fulvus*. Note that the regressed testis of some adult specimens weigh less than the testis of some juveniles.

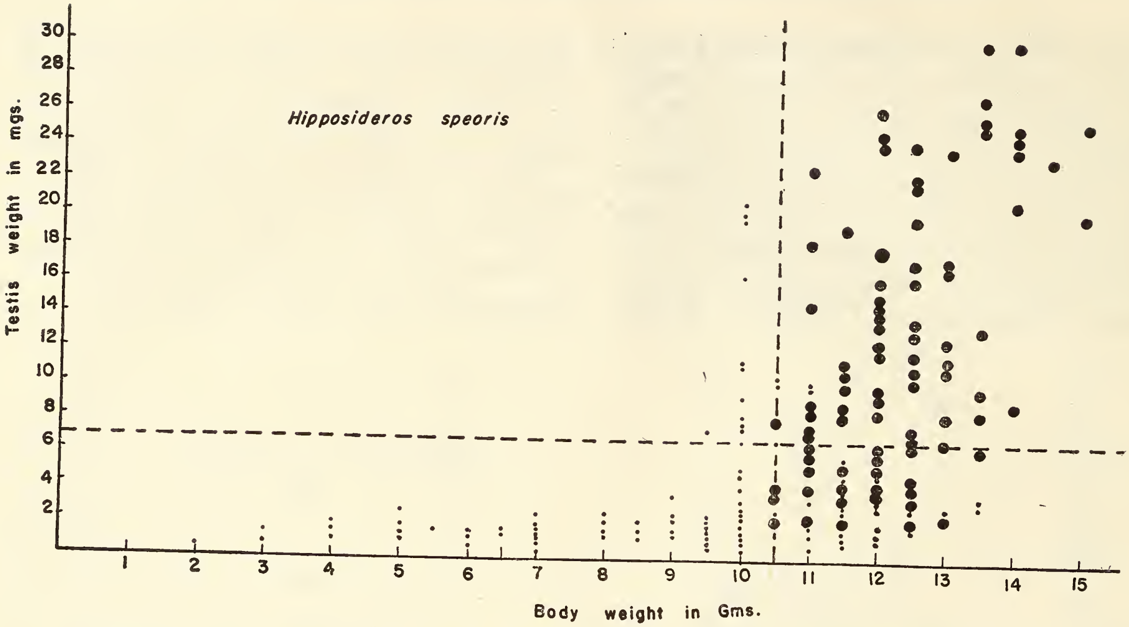

Fig. 10. Scatter diagram in which the testis weight is plotted against body weight in *Hipposideros speoris*. The situation is similar to that of *H. fulvus fulvus*.

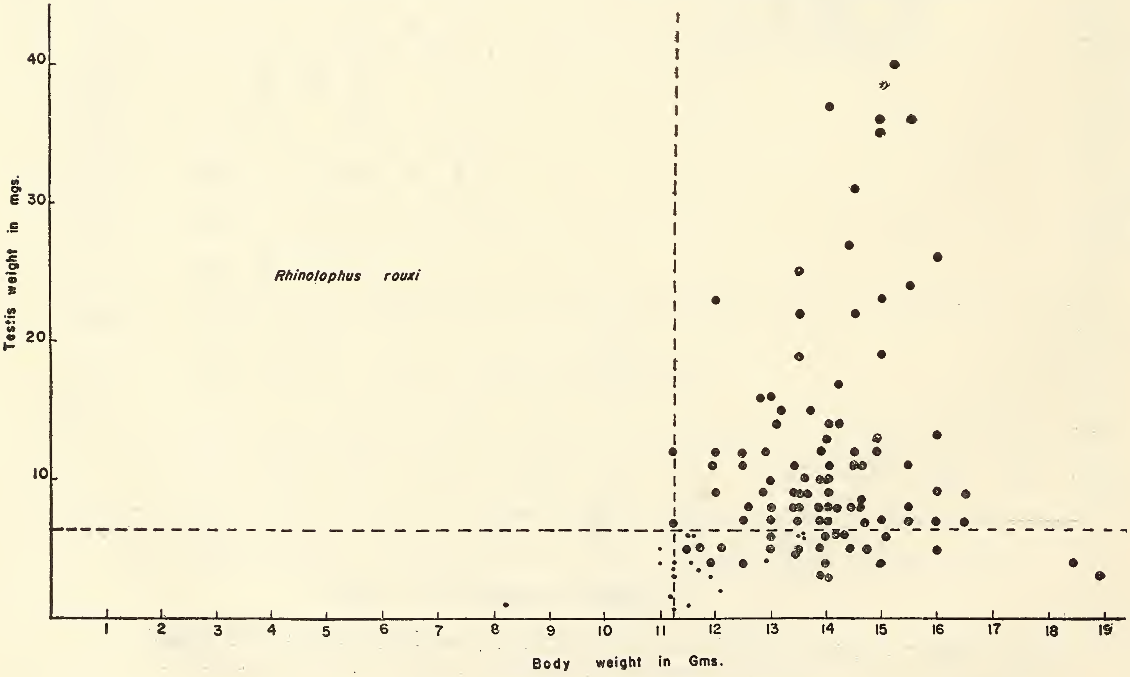

Fig. 11. Scatter diagram in which the testis weight is plotted against body weight of *Rhinolophus rouxi*. The situation is similar to that in *H. fulvus fulvus*.

Scotophilus heathi from Cochin

This species has been included in this study because it presents some interesting features in its breeding habits. Although near the equator, this bat has a strictly defined reproductive periodicity, and unlike the allied species, *Scotophilus temmincki* (Gopalakrishna, 1947, 1948, 1949), which breeds in March-April at Bangalore, this species comes to sexual activity in November-December, that is, it presents an autumn type of breeding pattern. The increase in the weight of the testis commences early in November and reaches maximum values during the last week of November and the first week of December. The testis undergoes regression and spermatogenetic activity ceases after the end of December. The changes in the testis weight are shown in figure 7. It has been already mentioned that even though the specimens copulate early in December, the inseminated spermatozoa remain viable and fertilise the ova released during the last week of December (Gopalakrishna and Madhavan 1978).

AGE AT SEXUAL MATURITY

In most bats the rate of growth of the body, as indicated by the increase in the body weight, is rapid and, hence, in most species the body weight cannot be used as a sure criterion for determining the age at sexual maturity except in *Rousettus leschenaulti* in which all female specimens above the body weight of 50 gms and all males above the body weight of 73 gms were mature (fig. 8). In other species no such direct correlation exists between the body weight and sexual maturity. Figures 9-11 are intended to illustrate this point in three species of bats. All these figures are scatter diagrams in which the testis weight is plotted against the body weight. The figures indicate that the body weight of some sexually immature animals may be more than that of sexually mature specimens. Similarly, the weight of the regressed testis of adults may be less than the weight of the testis of immature specimens. In the latter case the immature specimens represent animals approaching their first rutting season. But the pregnancy record in the female and the histological structure of the testis and the accessory reproductive organs in the males are reliable criteria to determine sexual maturity or otherwise in these animals. Further, in those species, which have pubic dugs, the size of the pubic dugs is an additional criterion to determine sexual maturity since the pubic dugs become enlarged during the first lactation as they are used by the sucking young for anchoring by the claws of their hind limbs. The dugs do not become reduced in size during the rest of the life of the females. Hence, the presence of large pubic dugs is a sure sign that the female had borne at least one young.

The normal method of calculating the approximate age at sexual maturity in those bats, which have an annual cycle in a sharply defined season, is to find out if immature specimens occur in the colony during the breeding season. The presence of immature specimens during the breeding season clearly indicates that the animals do not attain sexual maturity within the year of birth, and the earliest age of sexual maturity in these animals is the period from birth to the second breeding season of the species. It should, however, be mentioned that the animals may take even longer to attain sexual maturity, perhaps more than one breeding season after birth, but this is unlikely. On the basis of this criterion the bats having a strictly defined breeding season can be classified into two categories — (1) those which attain sexual maturity within the year of birth, and (2) those which do not attain sexual maturity within the year of birth. Further, while in some species the age at sexual maturity is the same in both sexes, in others there is a marked difference between the two sexes with regard to the age at sexual maturity, and in the latter cases the females reach sexual maturity at an younger age than the males. There are yet other species in which the age of sexual maturity varies on the basis of the season of birth in both the sexes. This situation is particularly conspicuous in those species which breed twice in quick succession within the year, for example, *Rousettus leschenaulti* (Choudhari 1968, Gopalakrishna and Choudhari 1977). In this bat the females born in March-April reach sexual maturity in November of the same year, that is, 7 to 8 months of age, and those born in July come to heat and experience their first breeding cycle in December, that is, about 5 months. Among the males those born in March-April come to rut and participate in copulation at an age of 19 to 20 months, while those born in July attain sexual maturity at the age of 15 to 16 months. This difference is probably due to the fact that the breeding season in this bat commences in October-November.

Among the other seasonally breeding bats the following species attain sexual maturity and participate in copulation in the year of their birth — *Scotophilus temminki* (Gopalakrishna 1947, 1948), *Pipistrellus ceylonicus chrysothrix* (Madhavan 1968, 1971), females of *Scotophilus heathi* (Madhavan 1981), *Hipposideros ater ater* (Gopalakrishna and Madhavan 1978), *Hipposideros speoris* (Bhatia 1980, Gopalakrishna and Bhatia 1984), *Tadarida aegyptiaca* (Kashyap 1980, Sandhu 1986) and females of *Tadarida plicata plicata* (Pendharkar 1981). The following species do not breed within the year of birth and probably attain sexual maturity and participate in copulation in the second year of their birth — *Rhinopoma microphyllum* (Sandhu 1986), *Rhinolophus rouxi* (Rao 1973, Gopalakrishna and Rao 1978), *Hipposideros fulvus fulvus* (Madhavan *et al.* 1977), *Hipposideros lankadiva* (Sapkal and Bhandarkar 1984), *Taphozous melanopogon* (Sapkal and Khamare 1984), *Taphozous kacchensis* (Deshmukh 1984, Sapkal and Bhandarkar 1985), *Megaderma lyra lyra* (Ramakrishna 1951, Ramaswamy 1961) and *Miniopterus schreibersii fuliginosus* (Gopalakrishna *et al.* 1985). It is not known with certainty whether the males of *Scotophilus heathi* breed within the year of birth although Madhavan (1981) suggested that they may attain sexual maturity within the year of birth.

In the cases of those species, which breed throughout the year, the above criteria cannot be applied for determining the age at sexual maturity. The only way to determine the age at sexual maturity in these bats is to band the newly born young ones and examine their genitalia periodically. No such work has been reported so far on any Indian bat.

INFLUENCE OF EXTERNAL FACTORS IN SEXUAL PERIODICITY OF BATS

An analysis of the data available on Indian bats indicates that no single external factor or a combination of external factors appear to be responsible for triggering the onset of breeding activity in these animals. This conclusion is drawn on the basis of the following facts: (1) Several species inhabiting the same locality and under similar ecological conditions have different patterns of reproduction and breed during different periods, and (2) the same species inhabiting different localities have a nearly same breeding pattern although in these cases the actual onset of breeding becomes slightly advanced towards lower latitudes. Evidently, factors such as temperature, rain fall, humidity, duration of the day etc. may not play a major role in establishing the reproductive periodicity in these animals. At best these factors may influence to a small extent so that delivery of the young ones may take place at the most advantageous season of the year. There is yet no evidence to indicate that food habits have any influence on the breeding pattern. It appears that the breeding rhythm is genetically determined for each species, and the influence of external factors, if any, is only marginal.

GENERAL CONCLUSIONS AND REMARKS

From the foregoing account, it appears that 'autumn' is the basic breeding season in the bats, and only a few species have adopted 'spring' as the breeding season. This conclusion is borne out by the fact that most species of bats, both tropical and temperate, come to sexual activity in autumn when they undergo copulation. The protracted storage of inseminated spermatozoa in the genital tract of the female in the autumn breeders of temperate regions appears to be an adaptation to bring forth the young ones in a season when there is abundant supply of food both for the mothers in lactation and the newly weaned young ones. The spring breeding in tropical bats is a modification of the same mechanism because even in these bats the time of delivery is so adjusted as to be most advantageous to the adults and the juveniles. A few bats like *Rousettus leschenaulti* and *Cynopterus sphinx* combine both autumn and spring breeding and form an intermediate stage of change over from the autumn breeding pattern of temperate species to the spring breeding pattern of some tropical species. A few tropical species, which breed throughout the year, form the extreme stage of evolution of reproduction in bats, and this is, perhaps, an adaptation to increase fecundity in these animals.

One of the interesting features of the reproductive biology of bats is the marked uneven sex-ratio with females out-numbering the males in the adult stage although the sex-ratio at birth is even. Such a feature has been reported in all the Indian bats so far studied (Gopalakrishna and Madhavan 1970, Gopalakrishna *et al.* 1985, Madhavan 1971) except in *Taphozous melanopogon* and *Hipposideros lankadiva* (Abdulali 1949). Evidently, there is a preferential mortality of the males during the growth period, and this is probably an adaptation to increase the potential reproductive population of the species. The only exception to this is *Taphozous melanopogon* (Abdulali 1949, Sapkal and Khamare 1984) in which the males outnumber the females in the colony. The available data do not permit an explanation for this anomaly. One interesting feature about this bat is that it is a seasonal migrator (Gopalakrishna 1986) and perhaps the males and the females live in different colonies except during the breeding season. Unless several colonies of this species are examined from different regions and during different seasons of the year, it is not possible to establish unquestionably that the males outnumber the females in this species. Earlier, *Hipposideros lankadiva* (Abdulali 1949) was described as having a male dominant sex-ratio, and this conclusion was based on the examination of one or two colonies once or twice in the year. But recent work on this species from several colonies and during all the months of the year has established that in this species also the females outnumber the males (Sapkal and Bhandarkar

1984). Perhaps a similar situation may obtain in *Taphozous melanopogon* also.

The low fecundity of most of the bats because of physiological asymmetry of the female genitalia and the animals being monotocous, and their having a single annual breeding cycle should normally reduce the population of the species progressively. Since this does not happen in the natural populations it is reasonable to assume that the bats must have a sufficiently long life so as to be able to produce at least 6 to 8 young ones during their life (allowing for the preferential mortality of the males during the growth period and for accidental death of the females). One could reasonably assume that the monotocous bats, which come to sexual activity in the second year of their birth and breed in a sharply defined breeding season, must have a longevity of at least 8 to 10 years to be able to produce 6 to 8 young ones during their life. Banding experiments alone can definitely determine the longevity of bats, but unfortunately no such experiment has been reported about Indian bats.

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HIGH FREQUENCY CINEMATOGRAPHY STUDIES ON LOCOMOTION AND PREYING IN INDIAN SKITTER FROGS *RANA CYANOPHLYCTIS* SCHNEIDER, 1799

RUDOLF ALTEVOGT,[1] HILTRUD HOLTMANN AND NORBERT KASCHEK

(*With two plates and three text-figures*)

High frequency cinematography (upto 1.500 frames per second) and flash photography recordings were made of the prey catching performance of the Indian skitter frog, *Rana cyanophlyctis*. The main temporal and spatial parameters thus found were compared to relevant data of other quick moving animals proving the skitter's pole position in view of acceleration and speed among jumping vertebrates.

According to Daniel (1974), "The commonest and most easily seen species of Indian frogs is the Skipper, *Rana cyanophlyctis*, a medium sized frog rarely exceeding 60 mm in snout to vent length. Almost all ponds, shallow stretches of rivers, rain water pools have their quota of this species easily recognized by their habit of skipping over the water like a ricochetting stone" (p. 392).

In fact, every Indian naturalist must have encountered the skipper when it heads in herds for the open water surface after the human intruder stirred them up from the bank of a reed- or bamboo-fringed pond.

Apart from the early report by Annandale (1919), the skater seems to have been studied in India only by Gans (1976), who noticed that "particularly, *Rana cyanophlyctis* was seen to skitter across the water", and "these frogs do not have to start well above the surface, but can start from a floating position, jumping free of the surface, and bouncing more than half a dozen times before either reaching land or diving to the bottom". Gans "filmed this behavior a number of times and in different localities" (in India and Sri Lanka).[2]

Unfortunately, Gans did not specify his film recordings, and quite apparently the usual shots taken at 24 frames per second do not tell the whole story.

This holds also true for some reports on other skittering frogs: Flower (1896) said that *Rana erythraea* "can hop over the surface of a pond, much as *Rana cyanophlyctis* does in India, and also jump right out of the water" (quoted from Romer 1951):

Romer (1951) extended these findings to *R. taipehensis* and stated "that both *R. erythraea* and *R. taipehensis* can hop over the surface of the water" (p. 414).

The phenomenon in question popped up outside India in short notes by Chabanaud (1949) on the African frog *R. occipitalis* which "dashes across the surface of the water, ricochetting over the surface by striking the water rapidly with its hind limbs", and he has

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[2] In the 16th Century, the Moghul Emperor Babur 1526-1532 commented that "The frogs of Hindustan are worthy of notice. Though of the same species, as our own, yet they will run 6 or 7 *Gaz* on the face of the water" — Eds.

"observed them crossing at top speed the full breadth of "marigots" some meters wide" (p. 288).

Dunn (1928) gives a similarly brief mention of the skittering locomotion in the East Indian *Rana macrodon.*

Blair (1950) has seen juvenile *Acris crepitans* (Hylidae) in Oklahoma (USA) "which were sitting along the bank (of a slough 6 to 8 feet wide, authors), and when disturbed almost invariably "bounced" two or three times on the water and landed on the opposite bank" (p. 237).

The same behaviour was reported by Hudson (1952) for this Hylid from the Delaware Canal (20 feet wide) in Pennsylvania, where "they exhibited skittering locomotion along the surface for a distance of 3 or 4 feet, then returned and swam rapidly back to the bank" (p. 185).

Finally, Janson (1953) referred to *Hyla cinerea cinerea* from North Carolina (USA) which "appeared unable to employ the skittering type of locomotion unless the starting point was well above the surface of the water" (p. 62).

Our frog is found from the Arabian peninsula to Thailand. Its remarkable ability to seemingly stride or skate across the water surface enables it to cover aqueous stretches of several meters in leaps and bounds. The observer's naked eye does not notice much more than circular patterns at intervals of some decimeters on the water surface, and for a more detailed analysis of the striding process, its beginning and its end, flash photographic and slow motion cinematographic recordings are needed.

Among the frog family Ranidae, *R. cyanophlyctis* is especially adapted to aquatic life, probably more so than any other Ranid species: due to some anatomical peculiarities involving pulmonar and other relevant features the skater can remain floating at the water surface for hours and hours without exerting much energy. And it is from this floating position that it can perform leaps of upto 50 cm height to catch insect prey passing by in flight. Similarly, from this position the fleeing reaction referred to above can be elicited.

To accomplish such feats, most, if not all other frogs need a solid surface as a launching pad.

To study these unique abilities, we brought four adult *R. cyanophlyctis* taken in the vicinity of Cochin, South India, to the lab. Surprisingly enough, the skippers are fairly sensitive to changes of their habitat and thus we had to condition them to jumping from the water surface for insect prey offered as flies and moths tethered on thin threads. There were two males weighing 4.9 and 7.8 g, both 39 mm long, and two females of 12.9 and 13.8 g body weight with 44 and 46 mm snout-vent length. Their aquarium measured 90 × 45 × 45 cm, and the water, kept at 24-26°C, was 25 cm high with a bottom substratum of fine gravel.

We wanted to analyse the prey catching action of the skipper by high frequency cinematography, i.e. extreme slow motion movies, ranging upto 1.500 frames per second instead of the usual 24 f/s. Thus, the happenings from take-off to aqua-landing would be slowed down by a factor of 62.5. We have a LOCAM camera 51-0002 from Redlake Corporation, Campbell, California, for upto 500 frames per second, and a HYCAM K 200/R from Red Lakes Labs., Santa Clara, California, for the higher frames. Illumination was done by 8 bulbs of 750 Watts each. The shots lasted from 3 to 10 seconds thus keeping low an increase of temperature, unavoidable when using such powerful lamps. Frame-to-frame analyses and the relevant drawings were done using the cutting-cum-editing machine S T 1201 from Steenbeck, Hamburg.

Contrary to common belief frogs are good learners: after few futile attempts to catch food dummies (plastic models of flies) they would no longer jump at them, though a live blowfly in a small glass vial would then again release the preying reaction. Again after about five trials when the fly could not actually be caught the frogs would stop and we had to switch over to tethered live flies offered at about 20 cm above the water surface.

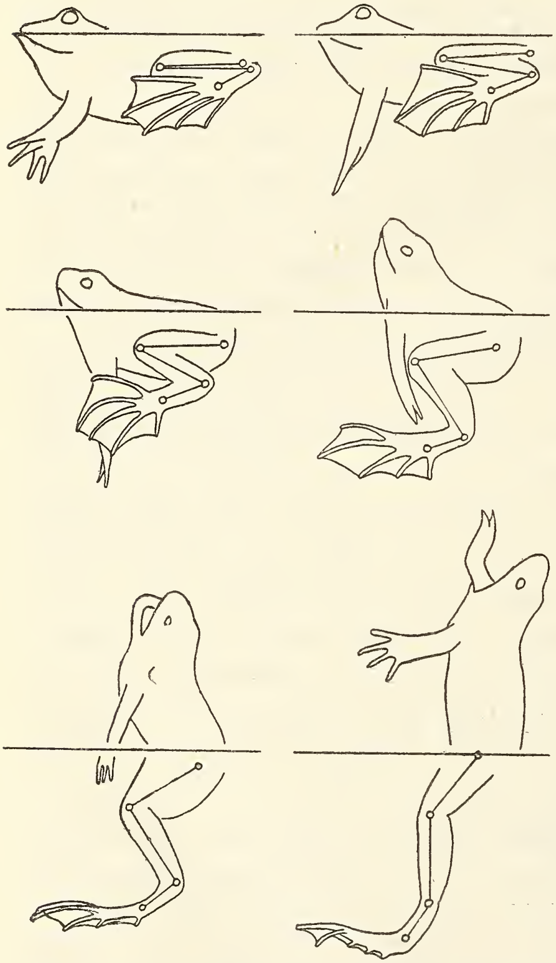


Fig. 1. *Rana cyanophlyctis*: start from the floating position. Time between successive phases: 0.013 seconds.

The typical habitat of *R. cyanophlyctis*, fresh water ponds, tanks and calm rivers without much water turbulence, is often shared by *R. hexadactyla.* Ecologically, they are nicely separated, however, in that *R. hexadactyla* prefers the vegetation belt near the banks, while *R. cyanophlyctis* is more often found in the open central areas, simply floating in the said manner. Unlike other frogs, in the floating skipper the longitudinal axis is almost parallel to the water surface (in the others dangling downwards considerably), and the hindlegs are held close to the body, in an angular position (fig. 1). Due to an apparently large lung volume — quantitative anatomical details still lacking — in some skippers a good part of the back and hindlegs is even protruding above the water surface (For further details on this floating posture and the functions of accompanying foot movements see Gans, l.c., and Holtmann 1985).

To maintain and re-orient this floating position, the skipper performs typical hindleg movements: about once per second both hindlegs are slightly moved backwards performing equilibrating movements at an angular speed of upto 463 degrees per second. When preparing to jump out of the water these movements are increased in frequency.

According to Satyamurti (1967) and Daniel (1975), the food of *R. cyanophlyctis* consists of insects, their larvae, and small vertebrates like frogs and tadpoles to which Minton (1966) added aquatic invertebrates like crustaceans and snails which are said to be caught under water. In our observations in the field and laboratory we saw only once that a conspecific tadpole of 8 cm length was swallowed by a skipper, but numerous small fishes (like *Lebistes reticulatus*) in our aquaria were never attacked by our skippers even when extremely hungry. When bluebottles (*Calliphora*) were offered along with waxmoths (*Galleria melonella*), the frogs at first would not show any food preference but after a few days they developed a definite preference for the moths. Even when *Calliphora* and *Lucilia* flies would no longer elicit prey capture, waxmoths would still trigger the jump for them. This fact shows that the skipper can very well distinguish such objects visually at distances of at least 20 cm. The neuro-ethological basis of this and similar behaviour features of anurans are at present under intense study in various laboratories (see Ewert and collaborators 1973, 1980).

The typical frog jumping from a solid substratum shows three separate acts: 1. take-off, 2. aerial phase, and 3. landing. The energy necessary for take-off is mustered in two stages, first by muscular forces of the hindlegs (*Musculus extensor femoris*) and the *Os cruris,* contributing the main part of the propulsion energy. After this first impulse, a second burst of muscular energy is released by stretching the tarsus, metatarsus and toes (Kamon 1971, Calow and Alexander 1973, Zajac and Levine 1979).

Energetically, a take-off angle of 45 degrees is optimal, as under this premonition the impulse is equally shared into its horizontal and vertical components (Gray 1968, Treff 1969, Luthanen and Komi 1978). Such ideal conditions, however, are hardly met with by the frog in its natural habitat, and jumps would be ideally ballistic only in flight reactions yielding maximum width at minimum energy expenditure.

More often, the frog's jump is aimed at prey, and their location and position make take-off diverge from that ideal angle. Schneider (1954) observed frog take-offs at 110 angular degrees, i.e. in a backward direction. At any rate, it is essential to gain propulsion energy for take-off in as high a fraction of time as possible (Hempel 1952, Gans 1961, Bennet-Clark 1974).

When taking off from the floating position, the skipper's femora and tibiae start the extension (i.e. stretching) movement from the folded position referred to above, both legs acting synchroneously if a straight forward and upward jump is needed. Otherwise, jumps to the left or right side are performed by metachroneously activating the right resp. left hindleg.

At the same time the forelegs are moved caudally by about 90 degrees so that they can come to rest along the ventro-lateral side of the body. This position enhances thrust and reduces water drag along the body's longitudinal axis (fig. 2).

Before act 2 of the take-off process (see above) is displayed, the skipper enlarges the surface of its heavily webbed hindfeet by abducing its toes spreading its metatarsal and phalangeal radii and thereby passively stretching its webs. As an example of this process and its energetic effects, the following data are illustrative: a male frog of 3.9 cm body length and 7.8 g body weight commands a web surface of 2.29 cm^2 per foot, and in a frog with 4.6 cm and 13.8 g this area amounts to 2.89 cm^2. Thrust pressure in such cases reaches values of 1.7 g and 2.38 g per square centimeter.

In exerting the take-off thrust against the water drag, the hindfeet assume a concave shape hence improving the hydrodynamic efficiency and reducing "slipping" of the feet in the water layers.

As stated above, in frogs starting from a solid surface, take-off angles of more than 110° have become known. They may relieve the

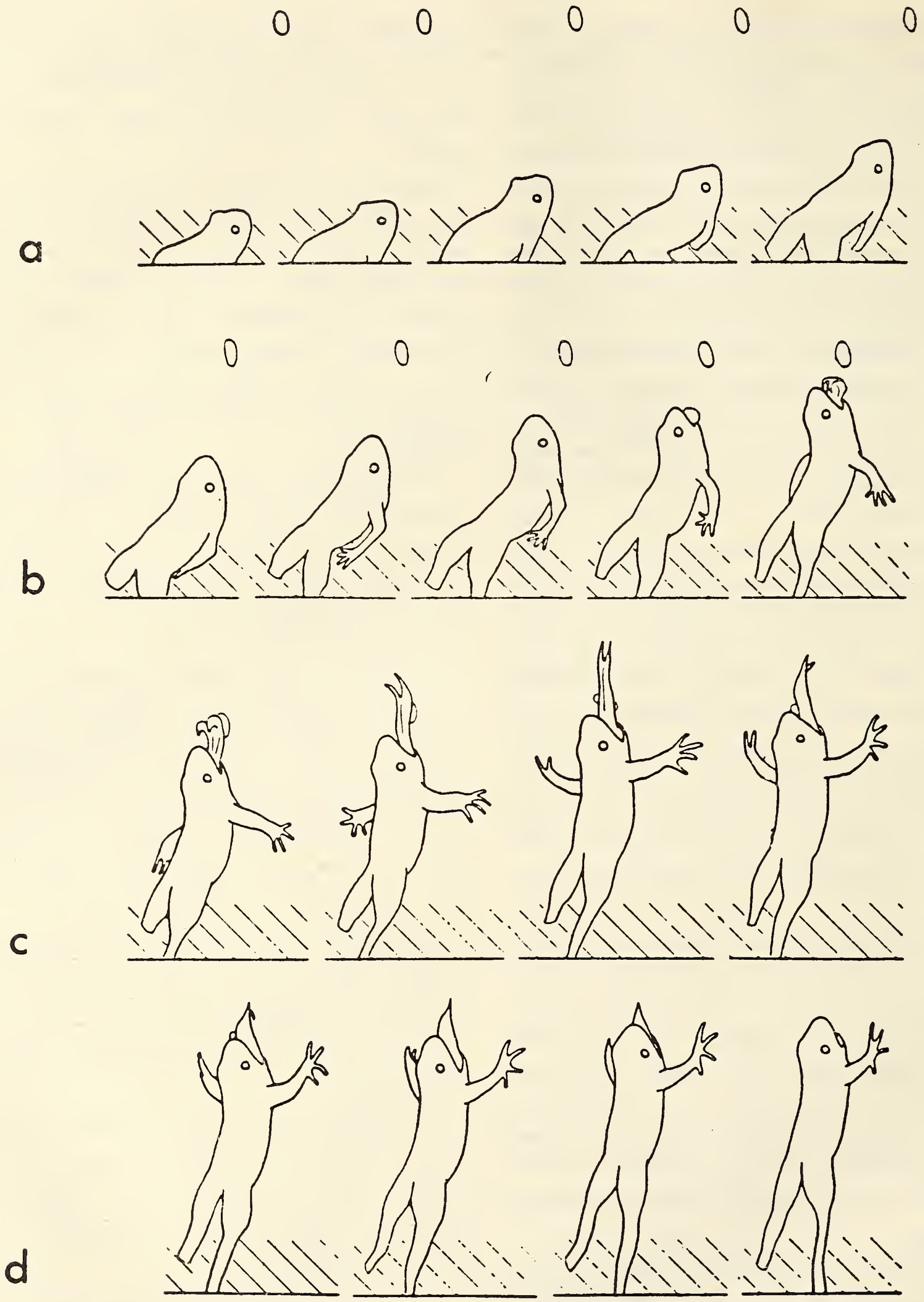
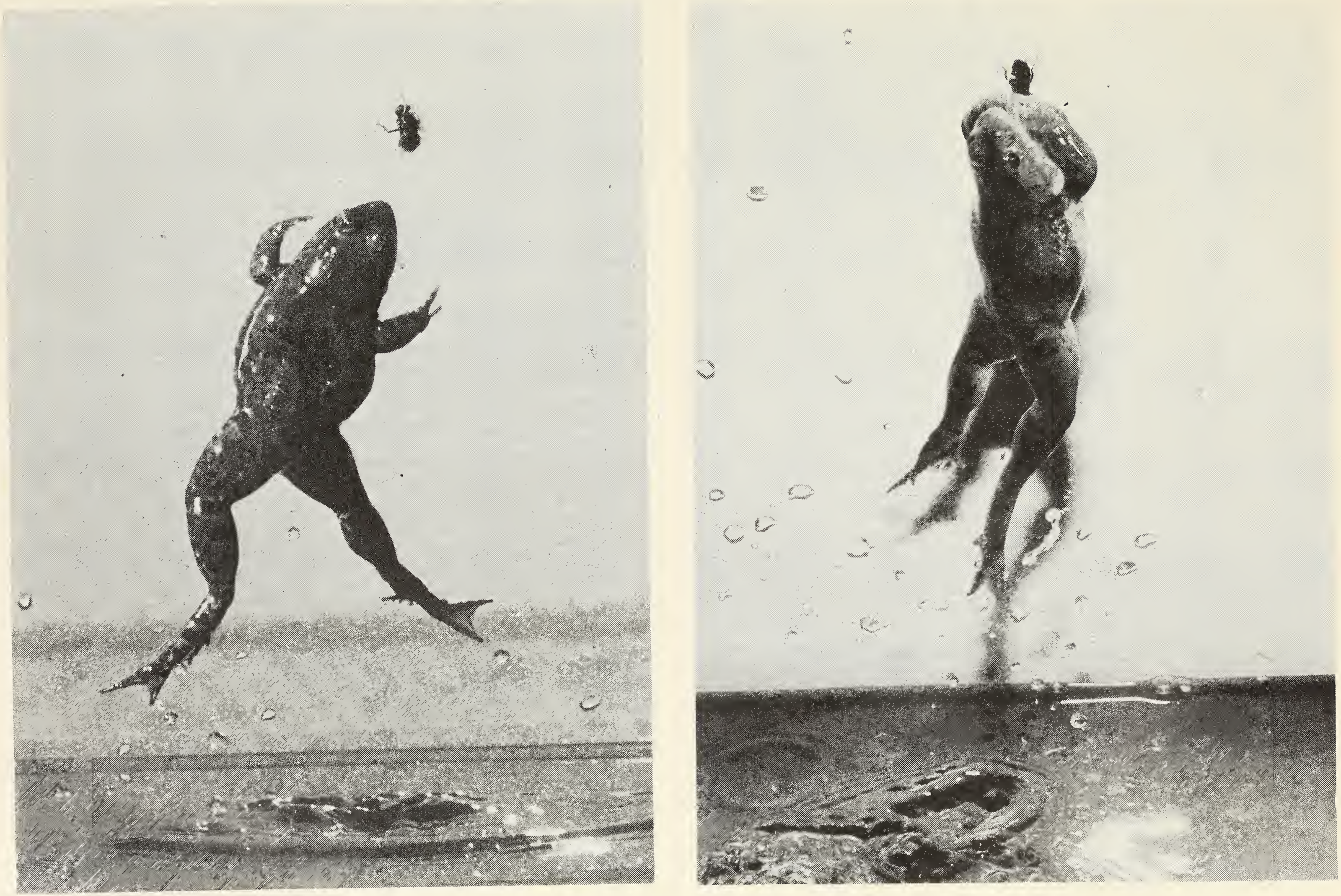


Fig. 2. *Rana cyanophlyctis*: Aqueous take-off, postural sequence, limb posture and tongue-action in prey-catching. Time between successive phases: 0.003 seconds.



Left: Fig. 3. *Rana cyanophlyctis*: Split-seconds after aqueous take-off, the fore-limbs are brought forward for gripping the prey. *Right*: Fig. 5. *Rana cyanophlyctis*: Fore-limbs help tongue in securing prey, eyes fully open.

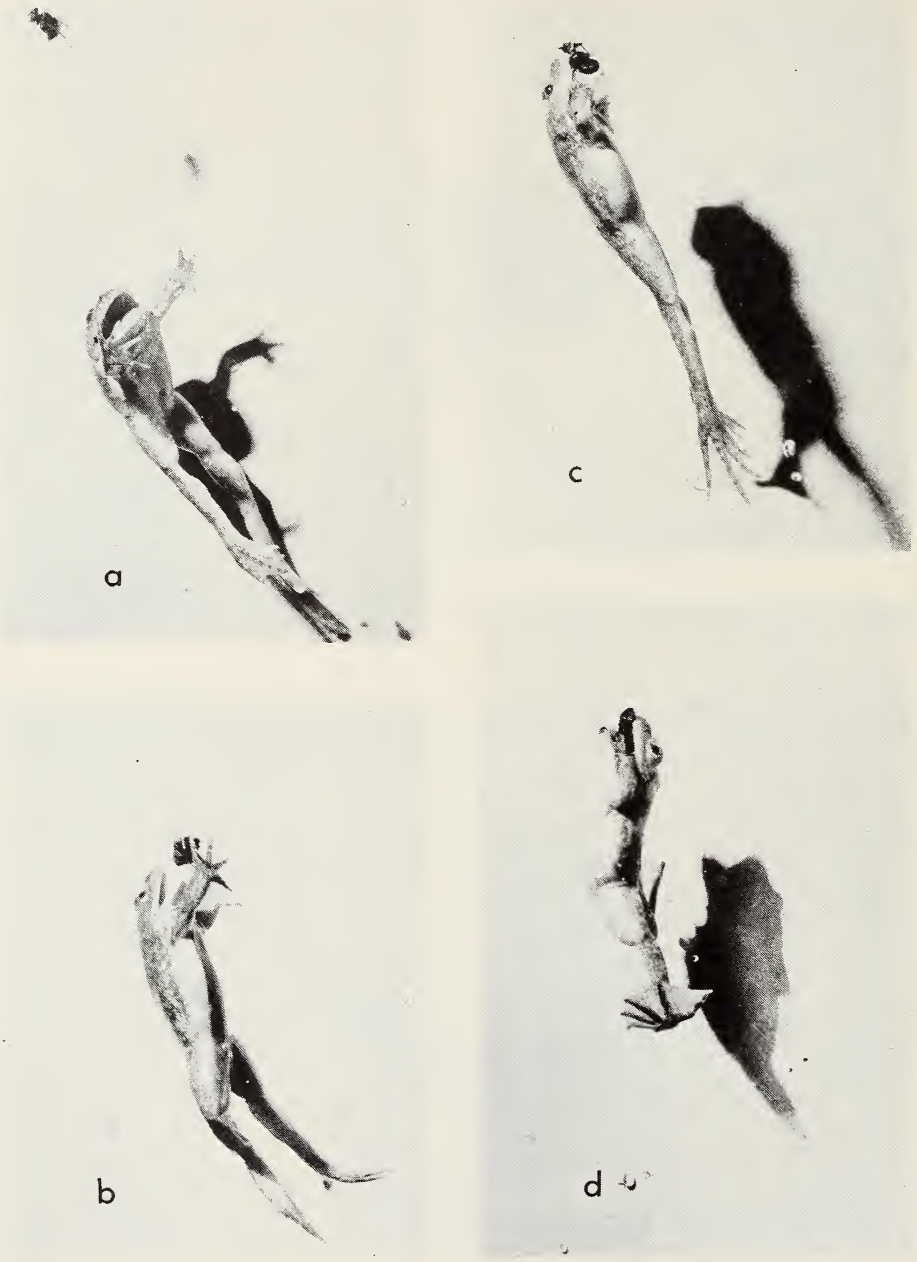


Fig. 6. Typical inflight-actions of *Rana cyanophlyctis* to catch a fly (a, b, c) and to alter aerial posture and flight course by extending foot-webs (d).
Photo flash 1/5000 sec.

frog from too much pre-start orientation movements by turning around its vertical axis in which possibly precious time may be lost during which the passing prey may have vanished for safety.

In aqueous take-off, skippers can also perform such shows attaining more than 100 angular degrees, i.e. doing a sort of backward somersault head over tail.

As can be seen from fig. 2, the take-off proper, i.e. from leg-stretching to clearing the water (phases b through d in fig. 2), takes roughly 5/100 seconds. If correction movements become necessary due to fast moving prey, skippers can respond within split seconds by horizontally turning round, covering 20 angular degrees in 0.013 seconds, i.e. one full round-turn takes only 0.234 s.

All these anatomical and physiological peculiarities enable the skipper to attain vertical take-off speeds of 3.3 m per second (equal to 11.9 km per hour) which places the skipper way ahead of *Rana temporaria* with 1.8 m/s (= 6.48 km/h) [Calow and Alexander 1973] and *R. ridibunda* with 1.4 m/s (=5.04 km/h) [Hirsch 1931] which, moreover, started from a solid launching pad and that, no doubt, provides much more favourable conditions than an aqua-take-off.

The skipper's performance is also ahead of the data ("estimated velocity") of nine species of Hylidae and *Gastrophryne carolinensis* (Microhylidae) from Mississippi reported by Zug and Altig (1978). Though in tree-frogs the physical and physiological parameters of their body seem to favour locomotion by leaps and bounds (as their name implies), the best jumper of these authors' lot attained only an estimated velocity of 2.2 m/s (=7.92 km/h). All this may not seem much if we compare the human high-jumper (3.28 m/s = 11.81 km/h; Luthanen and Komi 1978).

For a proper comparison, however, we should focus our attention on the acceleration data which, in the forementioned examples would read 10.35 m/s^2 in the human high-jumper, about 10 m/s^2 in the space ship launch, but 25.2 m/s^2 in *R. cyanophlyctis.*

For further comparison we tabulate the relevant data of acceleration and speed of a number of quick jumping animals some of which have been worked out in our laboratory using high speed cinematography and stroboscopy.

Unfortunately, the relevant data pertaining to the American bullfrog *Rana mugiens* Merr. cannot yet be included here from which Hesse and Doflein (1910) stated that it performs leaps of 2 m in length and easily crosses hedges of 1.5 m in height. Gans (1961), reporting on *R. catesbeiana,* the common American bullfrog, and showing beautiful flash photographs by M. F. Roberts, does not give quantitative data on acceleration and speed except that "segments of the frog's limbs are moving at speeds in excess of six feet per second" (p. 32) which would correspond to 6.48 km/h, i.e. to the speed of *Rana temporaria.*

The quickest space-ship with the fastest acceleration is not worth anything if not properly aimed at its target or destination. And though the average horizontal speed of a blowfly passing across a skipper's abode is only about 1.6 m/s (= 5.76 km/h, Schneider 1965) and the skipper's speed easily exceeds this mark, its body, gripping forelegs and tongue need to precisely zero in on the prey if the jump is to succeed. To do so, the frog, after clearing the water with forelegs still "folded" sideways in the ventro-lateral position along the body, propels both its forelegs snoutwards within one hundredth of a second (Plate I, fig. 3) and within the same short interval shoots out its tongue forward so that its

TABLE 1

VELOCITY AND ACCELERATION IN THE JUMP OF SOME VERTEBRATES AND INVERTEBRATES

	Velocity		Acceleration	Author(s)
	m/s	km/h	m/s²	
Mammalia				
Homo	0.03	10.91	9.55	Luthanen and Komi, 1978
Panthera			16.0	Bennet-Clark, 1977
Amphibia				
Rana ridibunda	1.4	5.04		Hirsch, 1931
Rana catesbeiana	1.8	6.48		Gans, 1961
Rana temporaria	1.8	6.48		Calow and Alexander, 1973
Rana cyanophlyctis	3.3	11.9	25.2	this paper
(Micro-)Hylidae	2.2	7.92		Zug and Altig, 1978
Insecta				
Cicadina/Auchenorrhyncha				
Philaenus spumarius	3.56	12.82	4750	Sitterle, 1984
Stenocranus major	3.95	14.22	2420	Sitterle, 1984
Aphrodes bicincta	3.3	11.88	2152	Sitterle, 1984
Aphrophora alni	3.96	14.26	5125	Sitterle, 1984
Siphonaptera				
Spilopsyllus	1.2	4.32	1330	Bennet-Clark and Lucey, 1967
Coleoptera				
Elateridae				
Athous	2.4	8.64	3800	Evans, 1972
Lacon	2.75	9.9	6875	Kaschek, 1984
Dalopius	1.74	6.26	2970	Kaschek, 1981
Histeridae				
Hister unicolor	0.25	0.9	107	Frantsevich, 1981
Atholus duodecimstriatus	0.60	2.16	1177	Frantsevich, 1981
Halticinae				
Tlamma	2.3	8.28	1344	Kleine, 1978
Haltica aenescens	1.26	4.54	189	Kleine, 1978
Mordellinae				
Mordellochroa abdominalis	0.69	2.48	190	Reuter, 1985
Anaspidinae				
Anaspis frontalis	0.23	0.83	63.33	Reuter, 1985
Saltatoria				
Locusta	3.2	11.52	180	Bennet-Clark, 1975
Collembola				
Sminthurus	1.4	5.04	970	Christian, 1978
Myriapoda				
Diopsiulus	0.48	1.73	39.0	Evans and Blower, 1973
Amphipoda				
Orchestia cavimana	1.01	3.64	202	Bracht, 1980
Hyale nilssoni	0.99	3.56	495	Bracht, 1980
Arachnida				
Sitticus	0.67	2.41	51.3	Parry and Brown, 1959; Denkler, 1977

Note: In most of the invertebrates mentioned here, the remarkable jumping data are due to various energy storing mechanisms.

two distal tips can nicely and firmly grip the prey (fig. 4). Speeds attained in these "arm" propulsions are upto 3 m/s. Both forelegs now serving as "arms" and hands in tucking the insect into the frog's mouth (Plate I, fig. 5), the successful jumper falls back into the water in a statistically haphazard manner: head or tail first or last, with the left or right side first touching down on and through the water surface.

Normally, after such successful jumps, the skipper dives to the bottom, devouring the prey and returning to its floating position for the next jump.

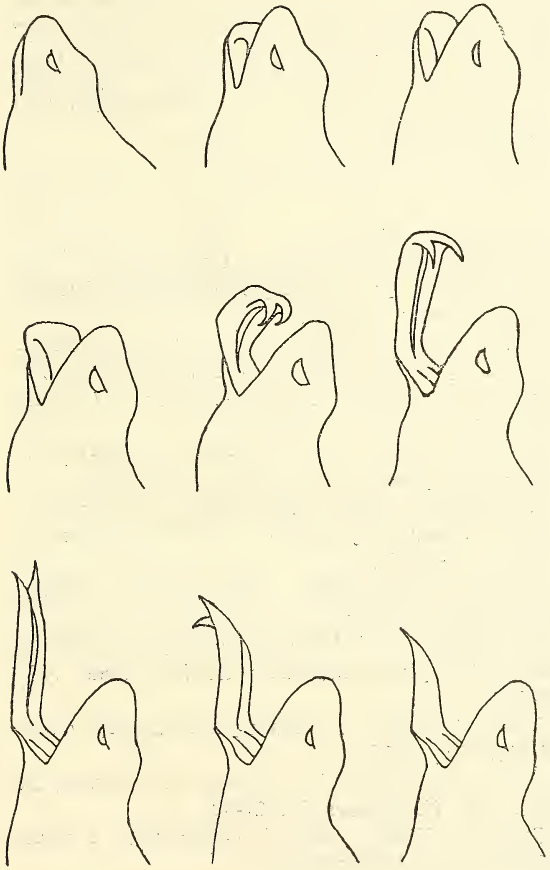


Fig. 4. Tongue action in *Rana cyanophlyctis*. Time interval between two successive phases: 0.003 seconds.

Even after being on its way after take-off, the skipper has two means of correcting its course and improving its aiming success. Not unlike the postural mechanism in a cat falling from a roof and making its landing on its feet rather than its back, skippers can alter their body posture and thus their trajectory by upto 25 angular degrees in flight. Hence they can to a certain extent overcome lateral displacements of their prey.

Another means of improving the zeroing in on the prey is provided by the tongue even while the frog is already in flight: the flicking movement of the tongue normally aiming straight forward as seen in fig. 1 and 2, can be laterally diverted to cover upto 25 angular degrees. Thus, even fast escaping flies can be caught.

Our high frequency shots of normal tongue actions yielded some more data highlighting its efficiency. The tongue in flight can be flicked out of the frog's mouth upto 20 mm distance, and it takes only 0.016 seconds to do so to full extension. The two sticky lobes of the tongue's tip envelop the prey and retract in within about the same short time into its buccal resting position. Gans (1961) reported 0.05 s in *R. catesbeiana* for the tongue to emerge and "less time than this" for retraction.

Another interesting retraction concerns the frog's eyes during the initial phases of its trajectory: they are retracted into their sockets. This is also proved in the excellent photos of jumping frogs by Roberts (in Gans 1961), and by Dalton (1982) on *R. temporaria* opining that one cannot think of an aerodynamic effect but rather of a means of protection for the eyes. In fact, Gans (1976) reported that skittering skippers hit a sloping rock upon the fourth or fifth bounce and flipped completely onto their backs: here protected eyes would certainly be advantageous.

On the other hand, however, protectively closed eyes would tend to impede visual (re-) orientation in flight, becoming necessary if, after take-off, the prey has moved away. Gans (1969) has drawn attention to this fact in the American bullfrog and thinks "that the nictitating membrane is thick, but transparent, and would seem capable of changing the optical qualities of objects seen through it" (p. 34). In our slow-motion shots, towards the end of the flight, before hitting the prey, the eyebulbs emerge again allowing for better visual input (Plate II, fig. 6c). No doubt, this is a prerequisite for the remarkable corrections, body, tongue and hands can perform, if the first attempt to grasp the prey proved futile.

Rüppell (1979) presented excellent flash photographs and slowmotion shots of *Rana esculenta* and emphasized the fact that the frogs can alter their trajectory while already in flight and perform correction movements apparently guided visually. In one example, after a frog missed and failed to envelop the prey, it fired the next correcting tongue shot a mere 9/100 seconds later. This, according to Rüppell shows "that the behaviour of our water frogs seems much more variable and adaptable to the relevant situation than one has thought so far". We hold that our quantitative data bear also witness to this fact for the skitter frog and would like to conclude these short notes with Gans, that "many things remain to be learned, even about the commonest animals, and it is obvious that photography can considerably assist the learning process" (1961, p. 37). We hope to learn more about the skittering method of *R. cyanophlyctis* in the near future.

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REDESCRIPTION OF THE CANE TURTLE WITH NOTES ON ITS NATURAL HISTORY AND CLASSIFICATION

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(*With a colour plate & three text-figures*)

Geoemyda silvatica, described in 1912 from two specimens collected in Kerala, India was rediscovered to science in 1982. This paper reports on the first direct observations by biologists of the species in its natural habitat along with observations of live captives and preserved specimens. The turtle is redescribed from 20 specimens including ontogenetic and sexual variation. Females tend to be slightly larger, relatively heavier and less colorful than males. Mature females develop a kinetic plastron through erosion of the bony suture between the hypoplastron and carapace.

The turtle, an inhabitant of hill forests above 300 meters altitude, is a secretive, nocturnal species. It is omnivorous, feeding on arthropods, mollusks, fruits and leafy vegetation. Two large brittle-shelled eggs are laid in the latter months of the year during the dry season.

The species was most recently placed in the genus *Heosemys* based on the absence of a post-orbital bar in the skull. However, it differs from other *Heosemys* in a number of significant characteristics. Comparisons indicate that it is most closely related to *Geoemyda spengleri* and thus should be returned to its original genus.

INTRODUCTON

Until mid-1982 the emydid turtle, *Heosemys silvatica* was known to science by only two specimens, collected in 1911. These specimens were obtained in the dense forest of south-western India near Kavalai, (*c.* 450 m) in the former 'Cochin State Forests', approximately 30 km east of Chalakudi, in the Trichur District, of Kerala. This locality is on the north-western fringe of the Anaimalai Hills, a region still supporting some areas of evergreen, semi-evergreen rainforest and more seasonal forest.

The first known specimen of *H. silvatica,* an adult male was collected by Kadar tribals (a semi-nomadic hill forest people) and presented to a collecting party headed by J. R. Henderson, superintendent of the Madras Government Museum. A second, immature specimen, was obtained by Henderson later in 1911 through a European living in Chalakudi. Although the original source of this specimen is unclear, probably it too was collected by the Kadars.

The type description of the species by Henderson (1912) was apparently based on both specimens although color notes and measurements were provided for the male only. The paper also included notes on natural history based on Henderson's observations of the two captives and on second-hand information from the Kadars who provided the specimens.

No further scientific information on the

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species was forthcoming for the next 70 years. It is now known that a few specimens entered the pet trade over this period but they were sold under the names *Melanochelys tricarinata* or *M. trijuga* (S. R. Sane-personal communication). In 1982 within a space of a few weeks, two researchers (J. Vijaya in July and P. Kannan in August) independently visited the vicinity of the type locality and obtained a living cane turtle female from tribals there.

Vijaya subsequently published a brief description of her specimen (originally reported as a male) along with notes on the turtles behavior in captivity and additional observations of the Kadar tribals concerning the natural history (Vijaya 1982 a, b, c).

We surveyed the Anaimalai Hills near Kavalai from October 26 to November 5, 1982. Our chief goals were to make first hand observations of the turtle under natural conditions, determine its conservation status and obtain several specimens for a captive breeding colony at the Madras Crocodile Bank Trust. For a general account of this trip see Groombridge *et al.* (1983). A shell and twelve living turtles were obtained (ten were observed under natural conditions). Five (1 male, 1 female, 3 juveniles) were marked and released at their collection site. Six (3 males 2 females, 1 juv.) were removed to Madras and placed in a semi-natural enclosure along with female previously obtained by Vijaya. One male was sacrificed for examination of internal and skeletal characteristics. Subsequently we have located and examined an additional eight turtles (2 living, 6 preserved) in museum and private collections including the type which is now in the Zoological Survey of India (ZSI 17115) collection in Calcutta.

Utilizing data collected from the above specimens, this paper: 1) expands the type description of *Heosemys silvatica* including information on ontogenetic, individual and sexual variation; 2) augments the meager knowledge of cane turtle natural history with first-hand observations of the species in the wild and with additional observations on the behavior of captive; 3) reviews the present classification of the species.

METHODS

For each of the twenty specimens examined, the following measurements were taken with vernier calipers in the manner depicted by Carr (1952) — length of carapace (CL); width of carapace (CW); length of plastron (PL) and the height or depth of shell (H); width of the bridge and of the anterior and posterior lobes of the plastron. Other measurements included length of plastral scutes, and length and width of the vertebral and nuchal scutes. Weights were taken on 8 living specimens.

Seam contacts of the five pleural scutes with the marginal scutes were recorded using a modified system of Tinkle (1962). The number of the marginal scute contacted by each seam was recorded sequentially from anterior to posterior followed by one of these symbols <, M, >, indicating the contact was at the anterior, middle or posterior third of the marginal scute respectively. The neural formula used herein comprises the number of sides for each neural from anterior to posterior. In the case of hexagonal neurals > indicates that the broad end faces anteriorly while a < indicates posteriorly.

Color descriptions were made by comparing turtle coloration with swatchs of standard colors from the Naturalist's Color Guide (Smithe 1975).

Comparisons were made with *Heosemys grandis* (8) and *H. spinosa* (8) from the senior author's collection, and with *Geoemyda spen-*

gleri from the USNM collection (10) and R. Hirayama (2) and literature descriptions.

DESCRIPTION

External Features:

Heosemys silvatica is a small, terrestrial turtle (maximum size 131 mm CL) having a relatively low three keeled carapace and a strongly hooked upper mandible among its more prominent features.

The margin of the shell is smooth and rounded in older individuals but the posterior portion is moderately reverted in the young. The width of the shell tends to be slightly more than double its height. It is widest in the region of marginals seven and eight and highest between the posterior of vertebral one and the anterior half of vertebral two. The carpacial keels are prominent in all but the oldest individuals but the central one is widest and most pronounced. The lateral keels parallel the central one anteriorly but converge towards it along the posterior half of the shell.

The five pleural scute seams contacted marginals 1 > (90%) — 5 M (80%) — 7 < (90%) — 11 < (65%) respectively for 20 individuals. Although the position of the contact on the marginal scute varied somewhat the scutes contacted (1, 5, 7, 9, 11) were constant except for one individual in which the fifth seam contacted M 10. The nuchal though absent from one individual is usually well developed. Nuchal underlap (length beneath the shell lip) exceeds the dorsal length of the nuchal, a common characteristic of terrestrial species.

Henderson (1912) reported that the vertebrals were broader than long except the last where length and width were approximately equal. In 20 individuals examined by us, this held true except that the length and width of vertebral 1 tended to be subequal (being wider in 55% and longer or equal in 45%). Vertebral 1 tended to be widest anteriorly (95%), whereas vertebrals 2-4 were widest in the middle third of the scute (100%) and vertebral 5 was widest posteriorly (100%).

The longest median seam of the plastral scutes is usually between the abdominals (90%) whereas the shortest is between the gulars (95%) or the anals (15%). Both gulars and anals are conspicuously notched at the midline. Axillary and inguinal scutes are usually present (67%) but tiny. The posterior lobe of the plastron usually exceeds the width of the bridge (95%).

The skin on the posterior dorsal surface of the head is divided forming a series of irregular shaped shields. The granular strip of skin posterior to the eye is relatively narrow usually comprising but two scale rows at the eye. The tongue is broad, fleshy and villose in appearance being covered with relatively long, flat, pointed projections.

The forelimbs are heavily armored anteriorly with enlarged, imbricate, squarish to pentagonal shaped scales extending onto the toes and soles of feet. On the hind limbs, enlarged scales are confined to the posterior-medial surface except for the feet where they cover the entire surface. A large pointed scale is present on each heel. Contrary to Smith (1931), the hind legs do not appear club shaped but have moderately elongated toes. The fifth toe is short and off set from the plane of the other four appearing as a small fleshy spur near the heel. Smith reported that the fingers are one-third webbed but usually the vestige of webbing is somewhat less than a third of the finger length.

Internal Features:

This account is based on one male (EOM 2644) dissected and skeletonized for study and the broken shell of a female (EOM 2622).

The internal choanae lack flaps and papillae, rather there is a simple ridge of tissue along the lateral border (Type C of Parsons 1960). Cloacal bursae are absent.

The penis (Fig. 1) is of the typical batagurine type (see Zug 1966). The plica externa is evident as a low triangular fold being somewhat more prominant proximally, its halves converging to an apex at the distal fibrous end. The plica media is a double triangular-shaped fold. The lateral portion is most prominant and is ornamented by a pair of rounded, medially projecting protuberances midway along its length. The medial fold is smaller, lower and has the well-developed flap-like plica interna attached at the proximomedial surface. A pair of sinuses (as indicated by lightened spots of tissue associated with a small papilla) are located on either side of the seminal groove between the proximal ends of the plica externa. When turgid, the penis is almost circular in outline and the folds of the plica media expand to cover most of the underlying structures, leaving only a small opening near the triangular distal end for the sperm to pass.

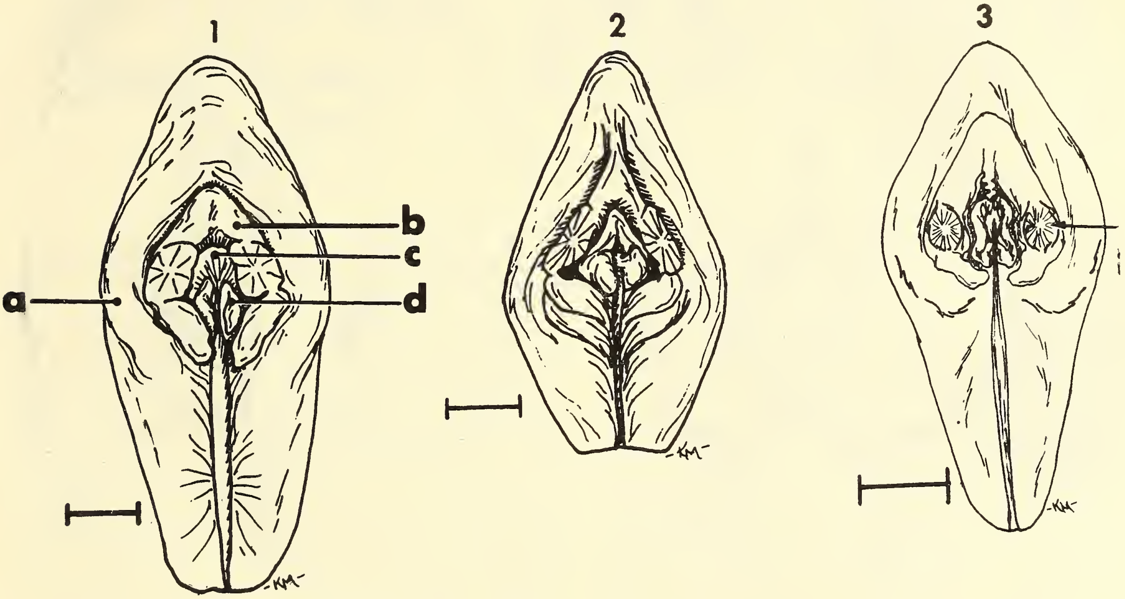


Fig. 1. Comparative penial morphology of 1. *Geoemyda silvatica,* 2. *G. spengleri,* 3. *Heosemys spinosa.* In no. 1 letter "a" indicates the plica externa, "b" the plica media (lateralis), "c" the plica media (medialis) and "d" the plica interna. The arrow in no. 3 designates a swollen protuberance on the lateral plica media shared by the three species. The scale marker represents 5 millimeters.

Skeleton:

While a complete description of the skull (Figs. 2 & 3) will not be attempted here, several features are of particular importance. The quadratojugal is absent leaving the jugal contacting only the maxilla and postorbital. This

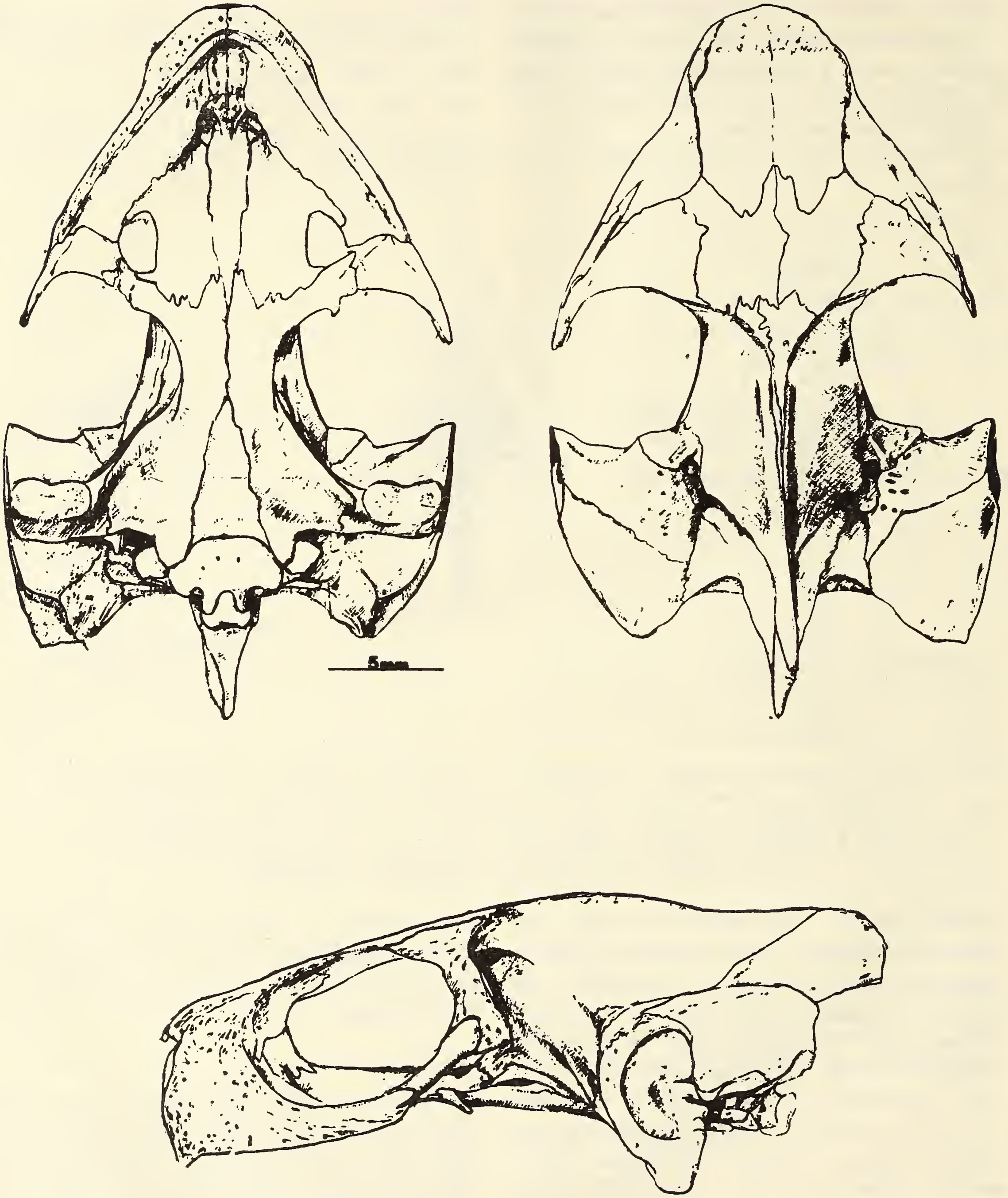


Fig. 2. Ventral, dorsal and lateral aspects of the skull of the cane turtle.

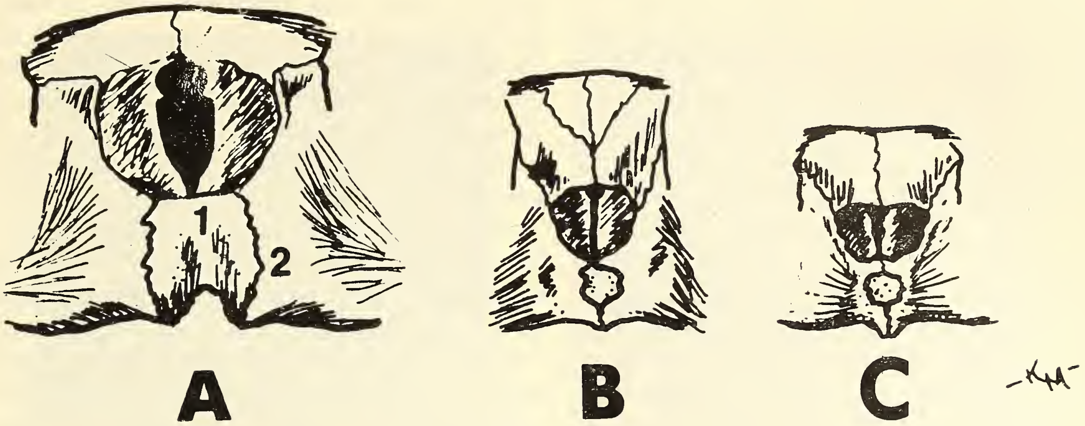


Fig. 3. Frontal view of the skull in A. *Heosemys grandis,* B. *Geoemyda spengleri* and C. *G. silvatica.* Numbers 1 and 2 indicate the premaxilla and maxilla respectively. The arrow indicates the fissure ethmoidalis (solid black).

characteristic occurs in other *Heosemys,* certain *Cuora* and *Hieremys* of the batagurines. The foramen palatinum posterious is moderately large *c.* 1.5 times longer than wide. The foramen orbito-nasale is tiny — a quarter to third the length of the palatinum posterious. The palatinum posterious of other *Heosemys* is larger and more elongate usually two or more times as long as wide and at least four times longer than the orbito-nasale. In *Geoemyda* and *Pyridea* the palatinum posterious is small being only slightly larger than the foramen orbito-nasale.

The frontal bone enters the orbit; its anterior processes are short and do not extend anterior of its lateral projections. The alveolar shelf is relatively narrow.

The anterior maxillae-premaxillae articulation is unusual among emydids and differs markedly from other *Heosemys* examined. Usually the maxillae do not contact anteriorly but in *silvatica* extensions of this bone meet at the anterior medial suture in two places: 1) above the premaxillae forming the inferior border of the external nares and 2) below the premaxillae at the apex of the tomium (margin of jaw) forming a projected hooked beak. The premaxillae thus appear as a small island surrounded by the maxillae (Fig. 3). In other *Heosemys* the premaxillae form the tomium anteriorly and instead of a projected hook, the midline is bicuspid — notched and flanked by a triangular projection on each side (Fig. 3).

The cervical articulations based on this one specimen is unusual in respect to the fifth and sixth vertebrae. In most batagurines the articulation here is single but this specimen has a double joint between 5 and 6, an emydine characteristic (McDowell 1964).

The neural formula for four shells examined was quite variable: A = 6<4-8-4-8-4-7-5; B=4-6>8-4-8-4-8-4; C=6<6< 6<4-8-4-6>6> D = 5-7-6<4-8-4-6>7. The most consistent feature of the formula was that neurals 4, 5 and 6 were 4, 8 and 4-sided respectively.

An unusual feature of the plastron is that the humeropectoral suture curves downward bordering the posterior margin of the entoplastron where it joins the hypoplastron. The plastral buttresses are weakly developed. The axillary buttresses attach to the carapace on costal 1 at the costoperipheral suture whereas the inguinal buttresses fuse to costal 5, again at the costoperipheral suture.

Coloration:

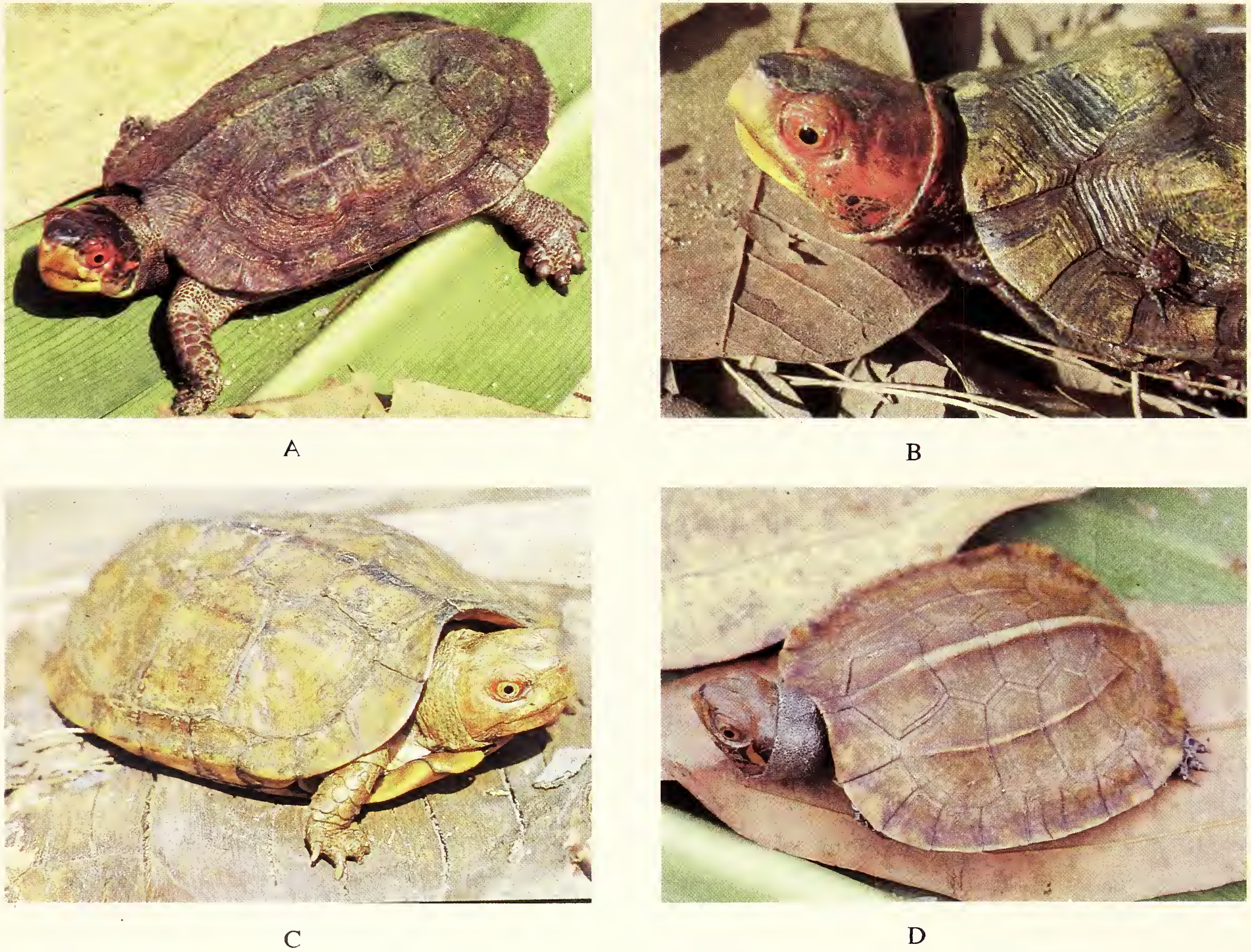
Although marked sexual dichromatism is relatively rare among the Testudines, it does occur in several batagurines (Moll *et al.* 1981). *Heosemys silvatica* has obvious sexual color differences. The descriptions below are based on color notes taken from 3 juveniles, 4 females and 4 males.

Juveniles are chiefly light brown (Pl. I-D). The carapace varies from cinnamon to clay and except for a somewhat lighter stripe along the central keel, is unicolored. The ground color of the head and neck is similar to that of the shell but is variously marked with orange. A pale orange post-ocular stripe runs from the eye, above the tympanum and ends at its posterior edge. Several orange tubercles dot the granular strip of skin between the tympanum and the eye. The clay-colored iris is surrounded by an orange sclera and eyelid. The dark background of the turtle's chin is also dotted with orange tubercles and the lower mandible has an orangish cast. A light clay stripe runs from the side of the nostril across the upper mandible to the angle of the jaws or may extend to meet the post-ocular stripe. The large shingle-like scales of the forelimb are dark brown with a narrow orange inferior border.

The venter varies from buff yellow to cream. A dark plastral figure is confined to the midline of the pectorals, abdominals, femorals and sometimes the anals. The bridge is dark brown.

Females maintain the juvenile coloration to a greater degree than males but differ in several respects (Pl. I-C). The largest individual observed had a dark brown stripe along the central keel and on the anterior third of each lateral keel. Otherwise the carapace is unpatterned, being somewhat more reddish than juveniles and varying from cinnamon to tawny or raw umber. Typical head coloration ranges from clay to cinnamon rufous. The largest again varied in that the coloration of the skin of the head and mandibles was a buff that had become heavily infused with red giving the overall appearance of a light brick red. The post-ocular stripe when present is a dull geranium pink (1 of 4 examined lacked the stripe). A light buff stripe extends from the snout over the top of the eye to the post-ocular stripe. The iris is amber to chrome orange and is surrounded by a scarlet to flame scarlet sclera. The mandibles are a dull buff which may be washed with red. The plastron tends to be buff to buff yellow but the central plastral figure is absent except for some scattered dark pigment along the seams. Brown pigment is still present on the bridge but this is relatively light. The skin of the limbs is dirty gray with the large scales being cinnamon brown to gray brown or grayish olive.

Males are generally darker and have brighter pink markings than females (Pl. I-A). The male coloration was also more variable than the females in the group examined. The head is usually black with a geranium pink snout and post-ocular stripe. The stripe may be complete or broken into parts. In one, the pink had expanded to cover the sides and much of the posterior of the head (Pl. I-B). Another variant was the largest (oldest?) male in which the post-ocular stripe was absent and the top and sides of the head were almost entirely black. The only pink on this indivi-



A B C D

Sexual and ontogenetic variation in the coloration of cane turtles from the Trichur District, Kerala.

(A) Typical coloration of an adult male (118 mm CL). (B) A young male (115 mm CL) with unusually extensive red head markings. (C) Coloration of an large adult female (131 mm CL). (D) Coloration of a juvenile. Note similarity of coloration to that of leaf litter.

dual was a pair of flat tubercles in the granular skin anterior to the tympanum.

The iris is usually flame scarlet surrounded by a scarlet sclera. The rim of the eyelid is geranium pink. Again the largest male varied by having a creamy white iris, a scarlet sclera and no pink on eyelid. The mandible is yellow to orange-yellow and considerably brighter than that of the female. The chin is a creamy white with scattered pink flecks. The skin of the forelimbs is dirty gray and the scutes on the anterior surface are olive brown.

The carapace is much darker than that of the female varying from burnt umber to dusky brown. Henderson (1912) characterized the coloration as uniformly black or almost dark bronze. The plastron is straw to sulfur yellow. The plastral figure is absent or reduced. In two individuals having the figure, one had only a black blotch on either side of the mid-femoral seam whereas in the other the dark figure was evident only at the midline on the femoral and anal scutes. In the latter, lines of dark pigment also extended laterally along the seams of the humerals, abdominals and femorals. The bridge and adjoining marginals are much more darkly pigmented (burnt umber to dusky brown) than that of females. The other marginals are the color of the plastron.

Previously we suggested that the bright coloration of the eye and head might be seasonal (Groombridge *et al.* 1983). This has not been confirmed. Captives at the Madras Crocodile Bank did not change appreciably in color over eight months of observations. Based on this small sample there may be an ontogenetic change, however, with older males tending to lose the bright red markings.

Sexual Dimorphism:

In addition to the striking color differences, males and females differ in certain structural features easily observed externally. As is common in terrestrial and semiterrestrial turtles, the male has a concave plastron compared to females in which the plastron is relatively flat. Male *silvatica* have an elongated concavity involving the abdominal and femoral regions. A second dimorphic feature is the tail which is more elongated and thicker at the base in males. The length of the tail proximal to the cloacal opening easily exceeds the portion distal to it whereas in the females the proximal portion is the shorter.

Based on the data in Table 1, females tend to be somewhat larger and more massive than males. The composite male of the sample would measure in millimeters 115 CL — 81 CW — 99 PL — 40.5 H whereas the composite female would be 121 CL — 87 CW — 108 PL — 43 H. Although weights were taken for only a few, females seem to be much heavier than males of a comparable length. A small female (116 mm CL) length weighed 222 grams whereas the largest male examined (125 mm CL) weighed only 159 grams.

The most unusual dimorphic feature concerns the connection of the hypoplastron to the carapace. In males and immatures, the plastron is solidly joined to the carapace by a bony suture. As females mature, however, the bony connection between hypoplastron and the carapace begins to erode and is replaced by ligament. The plastron becomes somewhat more moveable, an adaptation which likely allows for the passage of the relatively large eggs which otherwise could not fit through the posterior opening of the shell.

Sexually dimorphic plastral kinesis (term of Waagen 1984) has been reported for several other batagurines. Anderson (1878) first reported that the hypoplastral-carapacial connection is ligamentous in female *Melanochelys tricarinata.* Smith (1931) and Moll (1985)

TABLE 1

STANDARD MEASUREMENTS OF LIVING AND PRESERVED *Heosemys silvatica* ARE ROUNDED TO THE NEAREST MILLIMETER AND WEIGHTS ROUNDED TO THE NEAREST GRAM. ALL KNOWN SPECIMENS ARE FROM KERALA. THE TYPE SPECIMEN WAS REMEASURED FOR THIS PAPER.

Field or Museum Numbers	Sex	Locality	CL	CW	PL	H	WGT
12L	Juv	Trichur District	58	48	47	20	—
2R	Juv	Trichur District	59	48	47	22	—
1L 1R	Juv	Trichur District	64	56	52	25	24
1R	Juv	Trichur District	67	55	53	25	—
8R	F(IM)	Ernakulam District	105	81	92	39	95
UF 52515	F	Kozhikode District	114	88	105	41	—
9R	F	Trichur District	116	87	110	45	222
11L	F	Trichur District	117	84	103	41	—
—	F	Idukki District	120	86	107	43	—
EOM 2622	F	Trichur District	125	87	109	—	—
—	F	Idukki District	127	91	113	47	—
—	F	Trichur District	131	92	119	46	245
10L	M	Trichur District	100	80	87	35	—
EOM 2644	M	Trichur District	113	78	99	38	134
12R	M	Trichur District	115	80	99	42	139
EOM 2890	M	Trichur District	118	81	104	41	157
ZSI 17115 (type)	M	Trichur District	120	82	104	44	—
10R	M	Trichur District	125	83	105	43	159

have confirmed this observation. Mertens (1942) later described a more extreme condition in *Heosemys spinosa* in which the erosion includes not only the hypoplastral-carapace connection but the lateral portion of the hyo-hypoplastral suture as well. Pritchard and Trebbau (1984) reported that the bridge of female *Rhinoclemmys* is poorly ankylosed posteriorly and the posterior butresses do not fuse to the carapace. In making comparisons for the relationship section of this paper, we discovered that the condition may also be present in *Geoemyda spengleri.* In one female examined (USNM 34053) the posterior portion of the hypoplastral-carapacial connection is not solid and appears ligamentous. This observation needs to be confirmed on additional specimens particularly on living turtles and skeletal material. The genera *Cyclemys* and *Notochelys* differ from the above in that both sexes develop the hinged plastron and ligamentous connection of plastron to carapace at maturity.

NATURAL HISTORY

All previous natural history information on *Heosemys silvatica* had been obtained second-hand from tribals or from observations on three captive specimens. The following observations on cane turtle natural history reported by Henderson (1912) and Vijaya (1982a, b, c.) are:

1. a terrestrial species inhabiting hill forests of Kerala above 1000 feet altitude.
2. herbivorous, feeding on fruits and other vegetation.

3. preyed upon by man (Kadars), wild dogs, leopards and other carnivores of the area.
4. secretive nocturnal or crepuscular forms hiding in short underground burrows or among spiny cane plants (*Calamus* sp.), under logs and within rock crevices during periods of inactivity.
5. two eggs are laid in a small depression on the ground.

Now that we have observed these turtles under natural conditions and greater numbers in captivity, we are able to support some of these observations while refuting others.

Habitat:

We observed cane turtles in an unlogged area of semi-evergreen hill forest on gentle to steep slopes at some 400 meters altitude. The most productive sites had a considerable undergrowth of herbaceous plants around one to two feet high. Turtles were either concealed beneath these plants or amidst the floor leaf litter. The three-ridged, light-colored shell of juveniles especially resembled the coloration and vein pattern of leaves among the litter making them particularly difficult to discern. The turtles appeared to be completely terrestrial. A small stream ran through the area but none were found closely associated with it.

In regard to Henderson's (1912) report that the turtles inhabit short underground burrows, we found no burrows in the vicinity of our collections. However, it is still possible that they may utilize burrows at other (drier?) times of the year.

The Kadar name for *H. silvatica*, 'churel amai', means cane turtle — cane referring to a plant species of the genus *Calamus* which is common in the area. Although the Kadar's report that the turtle uses this spiny plant as cover, we found none near the cane.

Diet:

Our findings contradict previous reports that the cane turtle is herbivorous. These reports were based on observations of captive individuals which showed a predilection for fruits and vegetables (Henderson 1912, Vijaya 1982 a, b, c).

A preliminary account of our survey (Groombridge *et al.* 1983) reported finding a millipede scute in feces of a wild individual. We now have analyzed fecal samples from 5 wild caught individuals (3 males, 1 female and 1 immature). Four of the five samples contained animal food comprising 20 to 70 percent of the total (Table 2). Millipede parts were most common and occurred in all four samples. Shells of gastropod mollusks were in three samples and one sample contained a buprestid beetle (possibly *Chrysoris stollii*).

In contrast, definitely identifiable plant material (pieces of leaves) occurred in only one sample. However, there was a great deal of material in all the samples which could not be definitely assigned to plant or animal. As soft fleshy portions of fruit which are readily eaten in captivity would digest rather thoroughly, some to all of this unidentified matter could be of such material. This remains to be demonstrated.

In captivity the six *silvatica* kept at the Madras Crocodile Bank Trust (MCBT) regularly ate the plant material offered. They have been seen feeding on bananas, jack fruit, pineapple, and tomatoes. The turtles were also fed carrots, greens, apples and cabbage which regularly disappeared but whether this was due to the turtles or wild rodents is not known. Two observations of carnivory were made by MCBT staff. One turtle was seen feeding on termites attracted to the electric light hanging

TABLE 2

ANALYSIS OF FECAL CONTENTS FROM FIVE *Heosemys silvatica* COLLECTED OCTOBER 30 AND 31, 1982 IN THE ANAIMALAI HILLS OF KERALA. IMPORTANCE OF EACH FOOD ITEM IS INDICATED FIRST BY THE PERCENT OF THE VOLUME IT COMPRISED IN EACH INDIVIDUAL'S GUT CONTENTS AND SECONDLY BY THE PERCENT FREQUENCY OF OCCURRENCE (PERCENT OF THE FIVE SAMPLES WHICH CONTAINED THE ITEM)

		Food Item				
Sample	Sex	Millipedes	Snails	Insect	Plant	Unident
1	M	70%	—	—	—	30%
2	M	10%	15%	—	—	75%
3	M	5%	15%	—	—	80%
4	F	10%	5%	30%	—	55%
5	Im	—	—	—	15%	85%
% Freq. of Occurrence		80%	60%	20%	20%	100%

in the enclosure. On another occasion a turtle was observed covered with small black ants. Everytime an ant approached the turtles jaws it made a sharp sideways jerk of the head simultaneously snapping the jaws. The observer felt the turtle was catching the ants rather than using this behaviour in defense against them.

Behavior:

Diurnal cycle — Our observations confirm a crepuscular-nocturnal cycle. Members of the captive population usually spent the daylight hours hidden beneath leaf litter emerging only at dusk or after to forage and move about. To quantify these observations employees of the Madras Crocodile Bank made regular checks of the turtle's enclosure through the day and night from mid-December through January recording the number of turtles that were active (exposed with heads out) (Table 3).

In 48 days of observation active turtles were recorded 47 times and 41 (87%) of these observations were at night. Of the latter, 27 (65%) were observed in the early evening (1900-2200). Both sets of observations deviated significantly from those expected through chance alone ($X^2 = 37.59$ $P<0.001$ and $X^2 = 7.19$ $P<.01$ respectively).

TABLE 3

ACTIVITY PERIODS OF CAPTIVE CANE TURTLES AT THE MADRAS CROCODILE BANK RECORDED OVER A 48 DAY PERIOD (DECEMBER 15, 1982 - JANUARY 31, 1983)

Time Day	Active Turtles Observed
0800	—
1000	3
1300	1
1600	2
	6
Night	
1900	16
2200	11
0100	5
0400	9
	41

Aggression and defensive behavior — Aggressive behavior though not widely reported in turtles is not uncommon (see Bury *et al.* 1979, Bury and Wolfheim 1973, Froese and Burghardt 1974, Harless 1979). On May 10, 1983 an aggressive encounter was observed between two of the captive males (118 mm CL and 115 mm CL) which had been removed from their enclosure and placed in a plastic tub along with two females. After approximately half an hour, the larger male was observed rapidly approaching the smaller with the head and neck partially extended and the mouth open. Upon reaching the smaller, the larger bit at its head causing it to withdraw into the shell. The larger then moved away but when the smaller again extended its head and neck the larger approached once again with the mouth gaping. This time the smaller turned its head away and tipped its carapace toward the aggressor again stopping the attack. The tipping of the carapace was very similar to the defensive behavior of the snapping turtle *Chelydra serpentina* described by Dodd and Brodie (1975). The large turtle attacked the smaller on two more occasions during an hour period of observation. The smaller never made any attempt to actively defend itself but assumed the tipped carapace posture on both occasions.

Another type of defensive behavior was observed in both sexes. Cane turtles when picked up frequently defecated. Males used the penis to push feces out of the cloaca. Interestingly, they continued to extend the penis outside of the tail even after all feces had been expelled. This behavior provided the investigators opportunity to examine the penis in a turgid state.

Reproduction:

On 22 December 1982, two eggs were discovered in the turtle enclosure at the Madras Crocodile Bank (Whitaker 1983). The small size of the opaque band that had formed on one of the eggs indicated that they had been laid within a couple days of that date. The eggs set in a slight depression in the sand substrate covered with leaf litter. They had hard brittle shells that measured 44 mm x 22.5 mm and 45 mm x 23.5 mm. Unfortunately the only egg to develop an opaque band (indicating its viability) was broken either by the turtle or by the discoverers. No weights were taken at the time of discovery but the intact egg (smaller) weighed 15.25 grams on January 8.

Although it is uncertain which of two mature females in the enclosure laid these eggs, an examination on January 4 found that the plastron of the larger (131 mm CL) was particularly flexible at the ligamentous connection with the carapace. Assuming this female laid the clutch, the egg size indices based on length (egg length/Cl × 100) and weight (egg weight/turtle weight × 100) would be 35.1 and 6.2 respectively. By comparison, a terrestrial emydid from the Nearctic (*Terrapene carolina*) had length and weight indices of 28.8 and 2.2 respectively. Batagurine emydids lay unusually large eggs compared to their body size and *Heosemys* are at the upper extreme of the group.

This observation adds credence to information from the Kadars that the turtle usually lays 2 eggs. These same tribals reported that the nesting season was in October and November.

CLASSIFICATION

The cane turtle was originally placed in the genus *Geoemyda* which then housed a variety of semiaquatic to terrestrial forms inhabiting both Oriental and Neotropical regions. McDowell (1964) reorganized the Emydidae largely on the basis of cranial anatomy and partitioned the genus *Geoemyda* into the genera — *Heosemys, Melanochelys, Rhinoclemmys* and *Geoemyda.* Although he examined no specimens, *silvatica* was included in the genus *Heosemys* alongwith *depressa, grandis, spinosa* and *leytensis* presumably because the skull lacks a temporal arch. A "Geoemyda Complex" was erected housing all the old members of the genus *Geoemyda* plus *Cuora, Cyclemys* and *Notochelys.*

McDowell's classification has been widely used (with modification) by present day workers but alternative classifications do exist. Wermuth and Mertens (1977) for example classified *Geoemyda, Heosemys, Melanochelys* and *Rhinoclemmys* as subgenera under the Genus *Geoemyda.* Bramble (1974) in reviewing the shell closing apparatus of emydids proposed a *Heosemys* complex including *Cuora, Cyclemys, Pyxidea* and *Heosemys.* However, he was unaware of sexually dimorphic plastral kinesis in certain genera at this time (see Moll 1985).

Having now had the opportunity to examine both skeletal and living material, we question the placement of *silvatica* with the genus *Heosemys.* The temporal arch has been lost in other batagurine lines independently (e.g. *Cuora flavomarginata, C. galbinifrons, Hieremys annandalii*) and hence cannot alone be diagnostic. Other skull similarities such as relatively large palatinus posterious foramina and tiny orbito-nasale foramina are shared by most members of the *Geoemyda* complex.

Conversely there are a number of significant differences between *silvatica* and the other *Heosemys.* Table 4 summarises a number of the differences and similarities. Overall we conclude the differences outweigh the similarities and indicate a different generic allocation of *silvatica.* One recent classification by Lorenz

Table 4

Comparison of *silvatica* with *Geoemyda* (*spengleri*) and *Heosemys* (*spinosa* and *grandis*) relative to 17 character states — "+" indicates the character is present. "–" absent and "±" an intermediate condition

No.	Character	*silvatica*	*Geoemyda*	*Heosemys*
1.	Hooked Beak	+	+	–
2.	Maxillae meet anteriorly excluding premaxillae from labial border of mandible	+	+	–
3.	Pterygoid does not contact Jugal	+	+	–
4.	Fissure ethmoidalis relatively narrow	+	+	–
5.	Choanae-Type C (Parsons 1968)	+	+	–
6.	Carapace with 3 prominant keels	+	+	–
7.	Cloacal bursae	–	–	+
8.	Pattern of dark rays on plastral scutes	–	–	+
9.	Sexual dimorphic plastral kinesis	+	+	±
10.	Postorbital bar present	–	+	–
11.	Posterior palatine foramina large and elongated	±	–	+
12.	Inferior process of parietal convergent ventrally narrowing cranial cavity	±	+	–
13.	Posterior margin of carapace strongly serrated	–	+	+
14.	Humero-pectoral seam transverses entoplastron	–	+	+
15.	Large bony shingle-like scutes on forearm	+	+	+
16.	Enlarged scutes on the sole of the foot	+	+	+
17.	Knob-like prominences on lateral plica media of penis	+	+	+

(1984) has already excluded *silvatica* from the genus. Following recommendations made by Mertens (1942, 1971), Lorenz lumped all members of the *Geoemyda* complex having a ray-like pattern on the plastral scutes (*dentata, depressa, grandis* and *spinosa*) into the genus *Cyclemys*. Those *Heosemys* lacking such a pattern (*silvatica* and *leytensis*) were not included nor was their generic allocation discussed.

Perhaps the most significant character for assigning *silvatica* to a new genus is the nature of the hooked beak. The aforementioned extensions of the maxillae which form the beak and surround the premaxillae is an unusual derived feature, rare among batagurines. We are aware of only one other member of the *Geoemyda* complex having this trait — the leaf turtle, *Geoemyda spengleri* (Fig. 3). This species like *silvatica* is a small, three keeled, terrestrial turtle.

The nominate race of leaf turtles *G. s. spengleri* has been reported from southern China, Viet Nam and Indonesia. Another race *G. s. japonica* occurs on Okinawa.

In addition to the hooked beak and the strong superficial resemblance, *silvatica* and *spengleri* share a variety of other characteristics not shared with *Heosemys* (Table 4). Among these the lack of contact between pterygoid and jugal bones of the skull and the absence of cloacal bursae are particularly noteworthy. Both species lack the ray type of plastral pattern. The plastral pattern of *spengleri*, a uniformly dark bridge and plastron except for a peripheral border of yellow, could have evolved into the small dark central figure of *silvatica* through a simple reduction in extent of the dark pigment.

Despite the distinct differences, we concur with McDowell (1964) that the genera *Geoemyda* and *Heosemys* are themselves closely related. Similarities in scutellation of the foreleg and foot and penial morphology (Fig. 1) support this conclusion. In certain traits *silvatica* is intermediate between the condition in the *Heosemys* and *spengleri* (Tables 4, Nos. 11 & 12) or is more similar to *Heosemys* (Table 4, No. 10).

In the framework of the McDowell (1964) classification, we recommend that *silvatica* be removed from the genus *Heosemys* and be included in the genus *Geoemyda*.

McDowell included two other species with hooked beaks (*Pyxidea mouhotii* and *Cuora flavomarginata*) as members of *Geoemyda*. It is beyond the scope of this paper to extensively evaluate the merits of this inclusion. We have not examined *flavomarginata* but it is worth noting that *mouhotii* does differ from *silvatica* and *spengleri* on one key feature. The premaxillae rather than the maxillae forms the beak in *mouhotii*. The jugal bone of *mouhotii* is similar, however, in not contacting the pterygoid. More comparisons are needed to clarify these relationships.

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ON THE TAXONOMIC STATUS OF *PSITTACULA INTERMEDIA* (ROTHSCHILD)

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(*With a text-figure*)

Specimens belonging to four species of Indian parakeets were studied for biochemical characteristics. A comparative analysis of the variations in haemoglobin, plasma albumin and enzymes lactate dehydrogenase and non-specific esterases on PAGE was made so as to understand the taxonomic affinities of parakeets with special reference to the little known Rothschild's parakeet, *Psittacula intermedia.* Such an analysis considered along with constant morphological differences between specimens of *P. intermedia* strongly suggests an independent identity of *P. intermedia* as a valid species. Sexual dimorphism in this species is identified for the first time.

Introduction

Psittacula intermedia the Rothschild's parakeet is known to science only from 7 skins in the Rothschild's collection of American Museum of Natural History (AMNH). Of these 7 specimens 6 are alike and the all-green seventh is believed to be an immature specimen. For description of the species and body measurements refer to Rothschild (1895) and Biswas (1959). Walters (1985) has elaborately discussed the taxonomic status of *Psittacula intermedia* on the basis of published literature. He has concluded that "there is no hard evidence at all in favour for *intermedia* being a hybrid, and all available evidence, (though inconclusive) points to it being a discrete taxon". Further he has suggested that the group be treated as a species owing to lack of information whether it would be a species or sub-species of *himalayana/cyanocephala/roseata* groups. In addition Walters (loc. cit.) has also remarked that "if it is not extinct, it is probably highly endangered" as live specimens have not been found for so many years. Sane (1975, 1977) the first of the authors of this paper in his letter to the Avicultural Society (1975) and as an appeal to Parrot Society, U. K. (1977), reported about an immature live specimen of *P. intermedia* in his collection.

2. Notwithstanding its rarity, each year between 1979 and 1984, one or two live specimens of this species were available in the Indian bird market most of which could not however be acquired by us due to restrictions under the Indian Wild Life (Protection) Act. These birds were reportedly trapped in the plains of Uttar Pradesh, around Mattiyar and Varanasi regions, along with Roseringed (*P. krameri*) and Blossomheaded (*P. cyanocephala*) parakeets. Some of these birds had the maroon shoulder patch. This year also (May 1985) we have received one of these

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wildcaught birds with a shoulder patch, resembling Rothschild's description of *P. intermedia* but sent to us as a mutation of *P. cyanocephala.*

3. One of the Rothschild's parakeets in the Collection (Sane 1977) died in 1978 after getting an adult plumage. It did not have the maroon/red wing patched but was undoubtedly a male with developed testes. Another male in the collection, which is still living, had mated with a female Roseringed parakeet. However, the eggs laid were infertile.

4. These two specimens indicate that contrary to the assumption of Biswas (1959), the 6 skins of adult *P. intermedia* in the collection of AMNH are all females ! This is in marked contrast to the shoulder patch in other species of this genus where when present in one of the sexes (Blossomheaded, Slatyheaded) it is a character of the male or may be present in both sexes as in Rosyheaded (*P. roseata*) and Alexandrine parakeets. It is not clear to us as to how Biswas (loc. cit.) and others before him identified the all-green seventh skin in AMNH as an immature specimen of *intermedia* since it could as well be that of *himalayana.* But the sub-adult female received by us earlier this year was to begin with practically all-green, with only a faint suggestion of the maroon shoulder patch. As we write this paper in September 1985 the maroon patch has already become quite prominant as also the lilac on the sides of the head extending to the ears. The body measurements (see Table 1) of this female specimen are within the range of females in AMNH. The measurements of the two males of *P. intermedia* given below are fresh data on this species and suggest that the males are slightly larger than the females.

Table 1

A comparison of measurements (in mm) of *P. intermedia* holotype and paratypes with study specimens

Specimen	Wing	Tail	Bill	Remarks
1. Holotype	157	—	20.5	Preserved skin with maroon wing patch. Not sexed.
2. Paratype (5)	148, 155, 156, 155, 168	185, 202, 221	19, 20, 20, 21, 21	—do—
3. Specimen in BNHS Collection	L 153 R 151	223	21.5	Measured when the bird was alive. Sexed after death ♂, no wing patch.
4. ♂ adult with SRS	L 162 R 161	234	21.5	Living mated with Rosering. No wing patch.
5. ♀ Subadult with SRS	L 152 R 155	212	21	Living with a maroon wing patch.

5. One other sexual difference among Indian parakeets (in fact, parrots in general) well known to aviculturists is the thickness of the white ring in the eye. In Roseringed, Alexandrine and Blossomheaded parakeets the female has a slightly thicker white ring around the iris than the males. This also seems true of *P. intermedia.*

Colours of soft parts undergo considerable change soon after death and due to action of the preservatives. Given below is the description of soft parts of *P. intermedia* based on live specimens with us.

Beak: Similar in both sexes; the upper beak red, not the bright red of Roseringed or Alexandrine but a lighter shade of vermilion with pale margin all around. The lower beak is black which has not faded at all in the specimen in BNHS. The beaks of all three live specimens studied by us are as described here and not cream-yellow as in the colour illustration of Foreshaw (1973). It is noteworthy that the description of the holotype by Rothschild (1895) gives the colour of the "under mandible" as "orange-yellow". We suggest that the lower beak colour in holo and paraytpes may have been affected by chemicals used for preserving the specimens.

Call Notes: Generally very silent in captivity but we have heard the birds give a single syllable, loud, throaty call, not unlike that of Roseringed parakeet.

6. The use of biochemical characteristics to determine taxonomic relations is rapidly becoming popular (Ferguson 1980). An analysis of these characters, along with morphometric and ecological factors yields valuable information on the systematics of a species. For the present study we analysed variations in the biochemical characters such as haemoglobin (Hb), Plasma albumin (Alb) and isoenzymes Lactate dehydrogenase (LDH) and non specific esterases (Est) of 9 species of Indian parakeets. However considering the limited scope of this paper we have restricted the data to *P. intermedia* and 3 other Indian parakeets (*P. himalayana, P. cyanocephala* and *P. krameri*) which some authors, notably Hussain (1959) suspected to be the parent form of a hybrid, the Rothschild's parakeet !

The following is a report on this analysis:

MATERIAL AND METHODS

Blood samples each of *c.* 0.3 ml. were collected using a syringe, from adult parakeet specimens of different species in the collection of SRS, without killing the birds. The samples were centrifuged to separate red blood cells (RBC) from the plasma and the fresh plasma used as a source of the plasma albumin and enzymes LDH and Est.

The different proteins in the samples of plasma as well as Hb were separated by Polyacrylamide Gel Electrophoresis (PAGE) under carefully controlled factors like gel concentration (7.5%), pH of stacking (8.3) and running (9.5) gel, buffer system (Tris-glycine pH 8.3), voltage, current (4 mA per tube), temperature (4°C ± 1°C) the time of the run etc. Near constancy of these factors has facilitated a comparative analysis of the results. The dye bromophenol blue, mixed with the samples before loading on the gel columns in neutral glass tubes served as a marker. In each set of electrophoretic run one tube was loaded with human serum which served as a standard. For staining the gels after electrophoresis to identify the various specific proteins, we followed Gordon (1980) for plasma proteins, Brewer and Sing (1970) for LDH and non-specific esterases and Ornstein (1967) for Hb fractions.

Relative mobility (Rm) of each identified protein was calculated as a ratio of the distance travelled by the protein from the origin (base) as compared to the distance travelled by the marker in the same run. Each sample was analysed in at least 5 replicates. The mean Rm with a standard deviation from the mean for each identified protein band was recorded. Zymograms and protein profiles were prepared by plotting the Rm values. The band of the highest mobility was numbered 1 and those with successive lower mobilities were numbered 2, 3, 4 etc. as done by Ferguson (1980).

RESULTS AND ANALYSIS

Table 2 to 5 and Figure 1 include the data on Hb, LDH, non-specific esterases and plasma

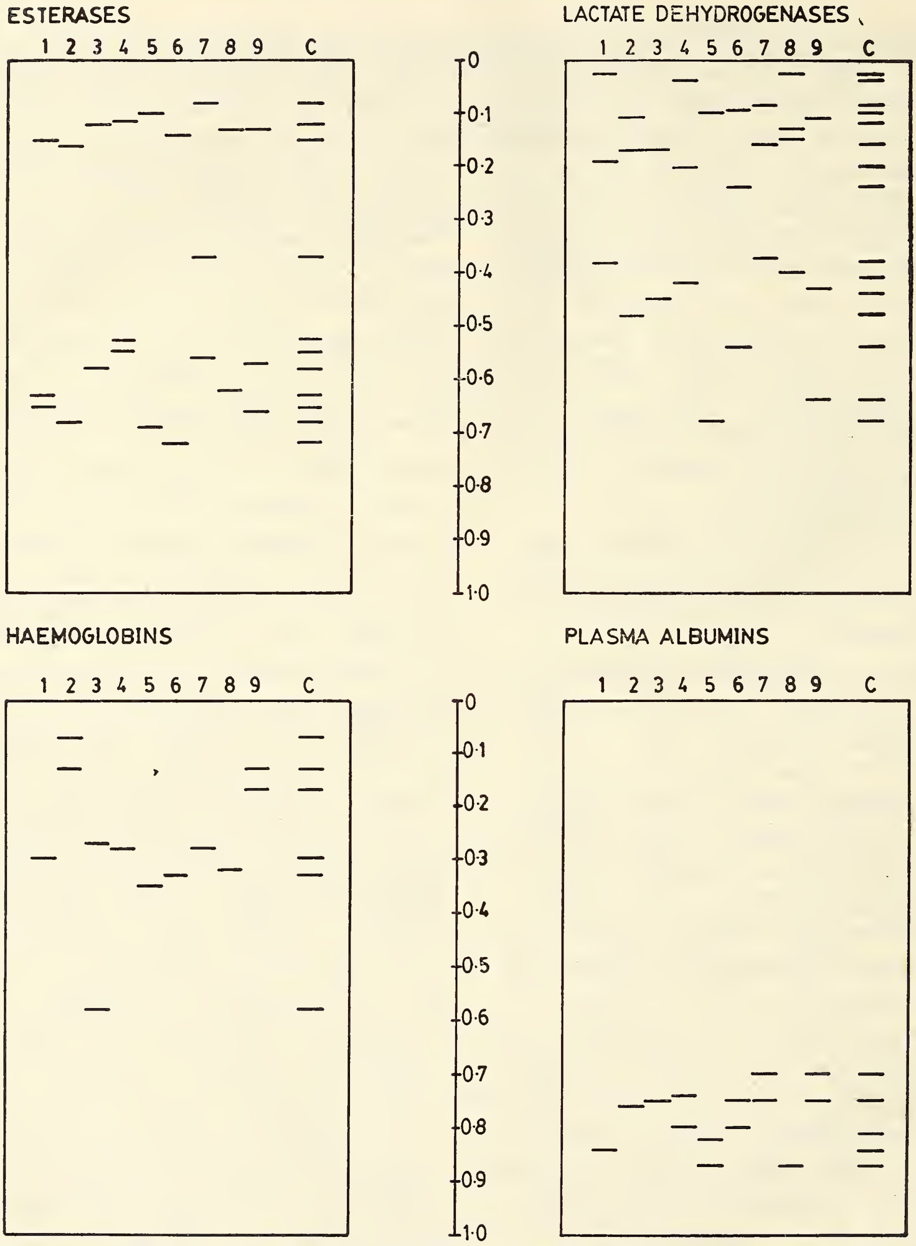
ESTERASES
LACTATE DEHYDROGENASES
HAEMOGLOBINS
PLASMA ALBUMINS
1 2 3 4 5 6 7 8 9 C
0
0·1
0·2
0·3
0·4
0·5
0·6
0·7
0·8
0·9
1·0

Fig. 1. Zymograms and Profiles of Esterases, Lactate dehydrogenases, Haemoglobin and plasma albumins from the nine species of *Psittacula*.

* (1) *P. intermedia* (Rothschild); * (2) *P. cyanocephala* (Linn.); * (3) *P. himalayana* (Lesson); (4) *P. alexandri* (Miller); (5) *P. derbiana* (Fraser); (6) *P. eupatria* (Linn.); * (7) *P. krameri* (Scopoli); (8) *P. calthorpae* (Blyth); (9) *P. columboides* (Vigors).

* Species described in the present paper.

TABLE 2

VARIATIONS IN RELATIVE MOBILITIES (RM) OF HAEMOGLOBIN FRACTIONS FROM FOUR SPECIES OF *Psittacula*

Species number					Hb band
1	2	3	4	C++	number
	0.07 ±0.005			0.07 ±0.005	6
	0.13 ±0.007			0.13 ±0.007	5
				0.17 ±0.01	4
0.03 ±0.001		0.29 ±0.01	0.29 ±0.007	0.30 ±0.01	3
				0.35 ±0.01	2
		0.58 ±0.01		0.58 ±0.01	1

Mean and S.D. of five replicates.
++ Consolidated pattern for Hb from *Psittacula* sp.
1. Rothschild's
2. Blossomheaded
3. Slatyheaded
4. Roseringed

albumin profiles of the four parakeets studied for this work.

Hb profiles of Blossomheaded and Slatyheaded parakeets had a two band pattern. Blossomheaded had Hb fractions of lesser mobilities Hb6 and Hb5 than Slatyheaded and Rothschild's parakeets. The Slatyheaded parakeet, though with a two band pattern, had one band, Hb1, of the highest mobility which it did not share with any other Indian parakeet and a second fraction, Hb3, that was in common with the single band of Rothschild's and Roseringed parakeets. Thus the Hb profiles of only the Roseringed and Rothschild's resembled each other.

The plasma albumin profiles of all four species showed that relative mobilities of their albumin bands were within a very narrow range Rm — 0.7 to 0.87, within which there were five distinct bands. Roseringed had a two fraction plasma albumin profile and the other three of only a single fraction. However, the Rm of the single fraction of Rothschild's parakeet was much greater being at Alb_2 than the other two with the plasma albumin fraction at Alb_4, in which position we also found one of the two fractions of Roseringed parakeets. The plasma albumin profile of Rothschild parakeet was therefore quite distinct from those of the other three species. The isozyme patterns for LDH are more varied in the nine species of parakeets, studied by us. Though a total of fifteen bands of activity were observed, on consolidation of all the patterns, the basic pattern appeared to be a three band pattern, observed in six species,

TABLE 3

VARIATIONS IN RELATIVE MOBILITIES (RM) OF PLASMA ALBUMIN FRACTIONS FROM FOUR SPECIES OF *Psittacula*

Species number					Hb band
1	2	3	4	C++	number
			0.70	0.70 ±0.001	5
	0.76 ±0.01	0.75 ±0.005	0.75 ±0.005	0.75 ±0.1	4
				0.81 ±0.005	3
0.84 ±0.01				0.84 ±0.01	2
				0.87 ±0.001	1

Mean and S.D. of five replicates
++ Consolidated pattern for Hb from *Psittacula* sp.
1. Rothschild's
2. Blossomheaded
3. Slatyheaded
4. Roseringed

TABLE 4

VARIATIONS IN THE RELATIVE MOBILITIES (RM) OF LACTATE DEHYDROGENASES FROM THE PLASMA OF FOUR SPECIES OF *Psittacula*

Species number 1	2	3	4	C++	LDH Bond number
0.025 ±0.003				0.026 ±0.006	15
				0.026 ± —	14
			0.086 ± —	0.086 ± —	13
	0.11 ±0.01			0.097 ±0.01	12
				0.12 ±0.008	11
	0.17 ±0.01	0.17 ±0.01	0.16 ±0.01	0.16 ±0.01	10
0.19 ±0.008				0.20 ±0.004	9
				0.24 ± —	8
0.38 ±0.004			0.38 ±0.005	0.38 ±0.005	5
				0.41 ±0.01	6
		0.44 ±0.005		0.44 ±0.007	5
	0.48 ±0.005			0.48 ±0.005	4
				0.54 ± —	3
				0.64 ± —	2
				0.68 ± —	1

Mean and S.D. of five replicates

++ Consolidated pattern for Hb from *Psittacula* sp.

1. Rothschild's
2. Blossomheaded
3. Slatyheaded
4. Roseringed

including the Rothschild's. Of the four species being analysed, the Slatyheaded was the only species with a two band pattern. Of the other three species, each having 3 bands, the Rm of bands were as follows: Rothschild's (LDH 7, 9 and 15), Blossomheaded (LDH, 4, 10 and 11) and the Roseringed (LDH, 7, 10 and 13). Thus the combination of bands for each species was distinct.

Analysis of Rm values for non specific esterases indicated that there were lesser variations in these fractions when compared with

TABLE 5

VARIATIONS IN RELATIVE MOBILITIES (RM) OF NON-SPECIFIC ESTERASES FROM THE PLASMA OF FOUR SPECIES OF *Psittacula*

Species number 1	2	3	4	C++	Est Band number
			0.08 ± —	0.08 ± —	11
		0.12 ±0.008		0.12 ±0.01	10
0.14 ±0.01	0.16 ±0.01			0.15 ±0.01	9
			0.37 ± —	0.37 ± —	8
				0.52 ±0.002	7
			0.52 ±0.004	0.55 ±0.01	6
		0.58 ± —		0.58 ±0.006	5
0.63 ±0.001				0.63 ±0.002	4
0.65 ±0.003				0.65 ±0.005	3
	0.68 ±0.006			0.68 ±0.006	2
				0.72 ± —	1

Mean and S.D. of five replicates

++ Consolidated pattern for Hb from *Psittacula* sp.

1. Rothschild's
2. Blossomheaded
3. Slatyheaded
4. Roseringed

LDH system. A total of eleven bands, Est$_1$ to Est$_{11}$, were identified as a consolidated pattern. Of the four species dealt with here fraction Est$_{10}$ was represented only in Slatyheaded. The overall pattern for esterases was three bands in Rothschild's and Roseringed parakeets; the other birds showed a two band pattern. Fractions Est$_1$, Est$_7$ and Est$_8$ were seen only in the Roseringed. The fractions of Rothschild parakeet were however at Est$_3$, Est$_4$ and Est$_9$.

DISCUSSION

During the past two decades, there has been an explosion of literature on biochemical aspects of systematics and organic evolution. Several authors (Uthe *et al.* 1965, Tsuyuki *et al.* 1965, 1966; Moller and Naevdal 1966, Selander *et al.* 1969, Yoshida *et al.* 1972 and De Smet and William 1978) have used the electrophoretic technique to identify species specific proteins. Ferguson (1980) has recognised that although this technique helped to establish differences between forms, it has not been successful in bringing out the similarities between them. The limitations of the technique are overcome in a comparative study of blood samples of various forms collected in an identical manner along with appropriate controls and the data analysed objectively. Adoption of this advice is the basis of this work to determine the taxonomic affinity of the Rothschild's parakeet.

Generally, haemoglobin is considered a stable molecule, useful in identifying similarities in taxa higher than species. Notwithstanding the slight differences in the number and Rm of haemoglobin fractions of the 4 species, the electrophoretic data confirms the essential taxonomic affinity between species of this genus. The Hb profiles of Rothschild's and Roseringed parakeets are nearly identical is noteworthy.

The esterases and albumin profiles are useful to identify the taxonomic difference at the species level. The higher Rm of the single Alb fraction is Rothschild's parakeet sets it apart from all others as a different species. The Rm of Est fractions of the Rothschild's parakeet is also quite different from the other three forms, which confirms its distinct identity. Even conceding that electrophoretic mobility of plasma proteins, especially of albumins and globulins, is easily affected by ecological factors including such environmental pollutants as insecticides, the difference in the Rm of Alb and Est fractions of captive specimens of the four species (sharing as they are a nearly identical environment) are interpreted by us as denoting interspecific differences. The marked differences in the Rm of serum LDH fractions of the four species are also similarly interpreted here as indicating the taxonomic differences at the species level, this despite the fact that physiological condition of individual specimens could influence the LDH fractions.

Thus a comparison of all the characters in the four species of parakeet studied strongly suggests an independent identity of the Rothschild's parakeet and we therefore agree with the opinion of Biswas (1959) that Rothschild's parakeet is a valid species.

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AN OVERVIEW OF THE AMPHIBIAN FAUNA OF INDIA

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INTRODUCTION

The last complete review of the Amphibia of India was Boulenger's in 1890. Since then many papers have been published describing new species (e.g., Rao 1937), revising certain species groups (e.g., Pillai 1978), or reviewing the species of a particular area (e.g., Daniel 1963, 1975). Through these publications and others cited below, the number of species of amphibians known to occur in India has more than doubled the 77 reported by Boulenger. Additions to the known fauna have not ended. The literature of the last 100 years has also added much to our knowledge of the distribution of Indian amphibians (e.g., Mahendra 1939, Jayaram 1974). Yet even a casual examination of Tables 1 and 2 in this paper will reveal that in this area, too, there is much to learn.

Given that so many basic facts concerning composition and distribution of the fauna remain to be gathered, we present this overview knowing that it will require serious revision in the future. Nonetheless, we believe its publication now is justified if for no other reason than to provide a summary of present knowledge. The relationship of the Indian fauna to those of adjacent areas can also be discerned now, even given the imperfect state of our knowledge. We present our view of that relationship. We are indebted to Mr. J. C. Daniel, who suggested that we consider this review.

SIZE AND COMPOSITION OF THE INDIAN AMPHIBIAN FAUNA

The variety of climates, vegetation, and topography encompassed by India (including here Sikkim and Bhutan) provide a great range of environments which leads one to expect a highly diverse fauna. The Amphibia reflect this effect, for at least 181 species occur in India (Table 1). Yet, as we will show below, there are good reasons for believing that the Indian amphibian fauna is still incompletely known and that the true diversity of the fauna is greater than just indicated.

All three extant orders of Amphibia occur in India: Caudata (salamanders) — 1 species; Gymnophiona (caecilians) — 15 species; Anura (frogs and toads) — 165 species. That only one species of salamander is found in India is not surprising, for the group is essentially temperate in its Asian distribution. Only three species occur south of China in eastern Asia, none south of the southern flank of the Himalayas and northern Burma, Thailand, and Vietnam. The caecilians, a small pan-tropical group with only about 160 species world-wide, had been little studied anywhere in the world until recently. Seven of the Indian species were described in 1960-1964 (Taylor 1960, 1964).

Frogs and toads make up 91% of species of Indian amphibians, which is just slightly

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TABLE 1

LIST OF INDIAN SPECIES OF AMPHIBIANS AND KNOWN OCCURRENCE IN STATES

Species	States
ANURA	
PELOBATIDAE:	
1 *Leptobrachium hasselti* Tschudi, 1838	Meghalaya
2 *Megophrys boettgeri* (Boulenger, 1899)	Assam, Arunachal Pradesh
3 *Megophrys parva* (Boulenger, 1893)	Sikkim, West Bengal
4 *Megophrys robusta* (Boulenger, 1908)	West Bengal
5 *Scutiger occidentalis* Dubois, 1977	Jammu & Kashmir
6 *Scutiger sikimmensis* (Blyth, 1854)	Sikkim, West Bengal
BUFONIDAE:	
7 *Ansonia ornata* Günther, 1875	Karnataka
8 *Ansonia rubigina* Pillai & Pattabiraman, 1981	Kerala
9 *Bufo abatus* Ahl, 1925	West Bengal
10 *Bufo beddomii* Günther, 1875	Kerala
11 *Bufo brevirostris* Rao, 1937	Karnataka
12 *Bufo camortensis* Mansukhani & Sarkar, 1980	Andaman Islands
13 *Bufo fergusonii* Boulenger, 1892	Andhra Pradesh, Karnataka, Kerala, Orissa, Tamil Nadu
14 *Bufo himalayana* Günther, 1894	Arunachal Pradesh, Meghalaya, Sikkim, West Bengal
15 *Bufo hololius* Günther, 1875	Kerala
16 *Bufo koynayensis* Soman, 1963	Maharashtra
17 *Bufo latastii* Boulenger, 1882	Jammu & Kashmir
18 *Bufo melanostictus* Schneider, 1799	all
19 *Bufo microtympanum* Boulenger, 1882	Kerala
20 *Bufo parietalis* Boulenger, 1882	Kerala
21 *Bufo silentvalleyensis* Pillai, 1981	Kerala
22 *Bufo stomaticus* Lutken, 1862	Assam, Bihar, Himachal Pradesh, Karnataka, Jammu & Kashmir, Maharashtra, Orissa, West Bengal
23 *Bufo stuarti* Smith, 1929	Assam
24 *Bufo viridis* Laurenti, 1768	Jammu & Kashmir, Punjab
25 *Bufoides meghalayana* (Yazdani & Chanda, 1971)	Meghalaya
26 *Pedostibes kempi* (Boulenger, 1919)	Meghalaya
27 *Pedostibes tuberculosus* Günther, 1875	Kerala
HYLIDAE:	
28 *Hyla annectans* Jerdon, 1870	Assam, Meghalaya
MICROHYLIDAE:	
29 *Kaloula pulchra* Gray, 1831	Assam, Karnataka, West Bengal
30 *Melanobatrachus indicus* Beddome, 1878	Kerala
31 *Microhyla berdmorei* (Blyth, 1856)	Meghalaya
32 *Microhyla chakrapani* Pillai, 1977	Andamans
33 *Microhyla inornata* Boulenger, 1890	Andamans
34 *Microhyla ornata* (Duméril & Bibron, 1841)	all
35 *Microhyla rubra* (Jerdon, 1854)	Assam, Kerala, Tamil Nadu, West Bengal
36 *Ramanella anamalaiensis* Rao, 1937	Kerala

TABLE 1 (contd.)

37	*Ramanella minor* Rao, 1937	Karnataka
38	*Ramanella montana* (Jerdon, 1854)	Kerala, Maharashtra
39	*Ramanella mormorata* Rao, 1937	Karnataka
40	*Ramanella triangularis* (Günther, 1875)	Karnataka, Kerala, Tamil Nadu
41	*Ramanella variegata* (Stoliczka, 1872)	Karnataka, Kerala, Madhya Pradesh, Orissa, Tamil Nadu, West Bengal
42	*Uperodon globulosus* (Günther, 1864)	Assam, Bihar, Karnataka, Madhya Pradesh, Maharashtra, Orissa, West Bengal
43	*Uperodon systoma* (Schneider, 1799)	Karnataka, Kerala, Orissa, Himachal Pradesh, Tamil Nadu, Uttar Pradesh, West Bengal
RANIDAE:		
44	*Amolops afghanus* (Günther, 1858)	Arunachal Pradesh, Himachal Pradesh, Meghalaya, Sikkim, West Bengal
45	*Amolops formosus* (Günther, 1875)	Meghalaya, Punjab, Sikkim, West Bengal
46	*Amolops monticola* (Anderson, 1871)	West Bengal
47	*Micrixalus borealis* Annandale, 1912	Arunachal Pradesh
48	*Micrixalus fuscus* (Boulenger, 1882)	Kerala
49	*Micrixalus nudis* Pillai, 1978	Kerala
50	*Micrixalus opisthorhodus* (Günther, 1868)	Kerala
51	*Micrixalus saxicolus* (Jerdon, 1853)	Kerala
52	*Micrixalus silvaticus* (Boulenger, 1882)	Kerala, Tamil Nadu
53	*Micrixalus thampii* Pillai, 1981	Kerala
54	*Nannobatrachus beddomii* Boulenger, 1882	Kerala, Tamil Nadu
55	*Nannobatrachus kempholeyensis* Rao, 1937	Karnataka
56	*Nanorana pleskei* Günther, 1896	Jammu & Kashmir
57	*Nyctibatrachus aliciae* Inger, Shaffer, Koshy & Bakde 1984	Kerala
58	*Nyctibatrachus deccanensis* Dubois, 1984	Kerala
59	*Nyctibatrachus humayuni* Bhaduri & Kripalani, 1955	Maharashtra
60	*Nyctibatrachus major* Boulenger, 1882	Kerala
61	*Nyctibatrachus minor* Inger, Shaffer, Koshy, & Bakde, 1984	Kerala
62	*Nyctibatrachus sanctipalustris* Rao, 1920	Karnataka
63	*Nyctibatrachus sylvaticus* Rao, 1937	Karnataka
64	*Occidozyga lima* Kuhl & Van Hasselt, 1822	West Bengal
65	*Rana alticola* Boulenger, 1882	Meghalaya, Sikkim
66	*Rana andamanensis* Stoliczka, 1870	Andamans
67	*Rana annandalii* Boulenger, 1920	West Bengal
68	*Rana assamensis* Sclater, 1892	Meghalaya, West Bengal
69	*Rana aurantiaca* Boulenger, 1904	Karnataka, Kerala
70	*Rana beddomii* (Günther, 1875)	Kerala, Maharashtra
71	*Rana bilineata* Pillai & Chanda, 1981	Meghalaya
72	*Rana blanfordii* Boulenger, 1882	Meghalaya, Uttar Pradesh, West Bengal
73	*Rana brachytarsus* (Günther, 1875)	Kerala
74	*Rana brevipalmata* Peters, 1871	Kerala, Tamil Nadu
75	*Rana cancrivora* Gravenhorst, 1829	Madhya Pradesh
76	*Rana crassa* Jerdon, 1853	Andhra Pradesh, Bihar, Kerala, Orissa, Tamil Nadu, Uttar Pradesh, West Bengal,

TABLE 1 (contd.)

77	*Rana curtipes* Jerdon, 1853	Karnataka, Kerala
78	*Rana cyanophlyctis* Schneider, 1799	all
79	*Rana danieli* Pillai & Chanda, 1977	Meghalaya
80	*Rana diplosticta* (Günther, 1875)	Kerala
81	*Rana doriae* Boulenger, 1887	Andamans
82	*Rana garoensis* Boulenger, 1920	Meghalaya
83	*Rana gerbillus* Annandale, 1912	Arunachal Pradesh, Meghalaya
84	*Rana hascheana* (Stoliczka, 1870)	Andamans
85	*Rana hexadactyla* Lesson, 1834	Andhra Pradesh, Gujarat, Karnataka, Kerala, Maharashtra, Orissa, Rajasthan (?), Tamil Nadu, West Bengal
86	*Rana intermedius* Rao, 1937	Karnataka
87	*Rana keralensis* Dubois, 1980	Kerala
88	*Rana khasiana* (Anderson, 1871)	Meghalaya
89	*Rana laticeps* Boulenger, 1882	Assam
90	*Rana leithii* Boulenger, 1888	Gujarat, Kerala, Madhya Pradesh, Maharashtra
91	*Rana leptodactyla* Boulenger, 1882	Kerala
92	*Rana leptoglossa* (Cope, 1868)	Assam, Meghalaya
93	*Rana liebigii* Günther, 1860	Jammu & Kashmir, Sikkim, Uttar Pradesh, West Bengal
94	*Rana limnocharis* Boie, 1835	all
95	*Rana livida* (Blyth, 1855)	Assam, Meghalaya, Sikkim, West Bengal
96	*Rana malabarica* Tschudi, 1838	Kerala, Madhya Pradesh, Maharashtra
97	*Rana mawphlangensis* Pillai & Chanda, 1977	Manipur, Meghalaya
98	*Rana minica* Dubois, 1975	Himachal Pradesh, Uttar Pradesh
99	*Rana murthii* Pillai, 1979	Kerala
100	*Rana nicobariensis* (Stoliczka, 1870)	Nicobars
101	*Rana nilagirica* Jerdon, 1853	Kerala, Tamil Nadu
102	*Rana phrynoderma* Boulenger, 1882	Kerala
103	*Rana sauriceps* Rao, 1937	Karnataka
104	*Rana semipalmata* Boulenger, 1882	Kerala
105	*Rana sikimensis* Jerdon, 1870	Meghalaya, Sikkim, West Bengal
106	*Rana sternosignata* Murray, 1885	Jammu & Kashmir
107	*Rana syhadrensis* Annandale, 1919	Maharashtra, Orissa
108	*Rana taipehensis* Van Denburgh, 1909	Assam, Orissa, West Bengal
109	*Rana temporalis* (Günther, 1864)	Karnataka, Kerala, Maharashtra
110	*Rana tenuilingua* Rao, 1937	Karnataka
111	*Rana tigerina* Daudin, 1803	all
112	*Rana travancorica* Annandale, 1910	Kerala
113	*Rana tuberculata* Tilak & Roy, 1985	Uttar Pradesh
114	*Rana vicina* Stoliczka, 1872	Himachal Pradesh, Jammu & Kashmir, Punjab, Uttar Pradesh
115	*Ranixalus gundia* Dubois, 1985	Karnataka
116	*Tomopterna breviceps* (Schneider, 1799)	Bihar, Himachal Pradesh, Kerala, Orissa, Punjab, Rajasthan, Tamil Nadu, Uttar Pradesh, West Bengal
117	*Tomopterna dobsonii* (Boulenger, 1882)	Andhra Pradesh, Karnataka, Tamil Nadu
118	*Tomopterna leucorhynchus* (Rao, 1937)	Karnataka
119	*Tomopterna parambikulamana* (Rao, 1937)	Kerala
120	*Tomopterna rolandae* Dubois, 1983	Kerala, Madhya Pradesh, Orissa, Tamil Nadu, West Bengal

Table 1 (contd.)

121	*Tomopterna rufescens* (Jerdon, 1854)	Kerala, Maharashtra
Rhacophoridae:		
122	*Chirixalus doriae* Boulenger, 1893	Arunachal Pradesh
123	*Philautus andersoni* (Ahl, 1927)	Assam
124	*Philautus annandalii* (Boulenger, 1906)	Assam, West Bengal
125	*Philautus beddomii* (Günther, 1875)	Kerala
126	*Philautus bombayensis* (Annandale, 1919)	Maharashtra
127	*Philautus chalazodes* (Günther, 1865)	Kerala
128	*Philautus charius* Rao, 1937	Karnataka, Kerala
129	*Philautus cherrapunjiae* Roonwal & Kripalani, 1961	Meghalaya
130	*Philautus crnri* Dutta, 1985	Karnataka
131	*Philautus elegans* Rao, 1937	Karnataka
132	*Philautus femoralis* (Günther, 1864)	Kerala
133	*Philautus flaviventris* (Boulenger, 1882)	Kerala
134	*Philautus garo* (Boulenger, 1919)	Meghalaya
135	*Philautus glandulosus* (Jerdon, 1853)	Kerala, Maharashtra
136	*Philautus hassanensis* Dutta, 1985	Karnataka
137	*Philautus kempiae* (Boulenger, 1919)	Meghalaya
138	*Philautus kottigeharensis* Rao, 1937	Karnataka
139	*Philautus leucorhinus* (Lichtenstein & Martens, 1856)	Kerala
140	*Philautus melanensis* Rao, 1937	Karnataka
141	*Philautus narainensis* Rao, 1937	Karnataka
142	*Philautus noblei* (Ahl, 1927)	Kerala
143	*Philautus parkeri* (Ahl, 1927)	Kerala
144	*Philautus pulcherrimus* (Ahl, 1927)	Kerala
145	*Philautus shillongensis* Pillai & Chanda, 1973	Meghalaya
146	*Philautus signatus* (Boulenger, 1882)	Kerala
147	*Philautus swamianus* Rao, 1937	Karnataka
148	*Philautus temporalis* (Günther, 1864)	Kerala
149	*Philautus travancoricus* (Boulenger, 1891)	Kerala
150	*Philautus variabilis* (Günther, 1858)	Andhra Pradesh, Kerala
151	*Polypedates leucomystax* (Gravenhorst, 1829)	Arunachal Pradesh, Assam, Sikkim, West Bengal
152	*Polypedates maculatus* (Gray, 1834)	all (except Haryana, Punjab, Rajasthan)
153	*Rhacophorus bipunctatus* Ahl, 1927	Arunachal Pradesh, Meghalaya
154	*Rhacophorus calcadensis* Ahl, 1927	Kerala
155	*Rhacophorus dubius* Boulenger, 1882	West Bengal
156	*Rhacophorus jerdonii* (Günther, 1875)	Arunachal Pradesh, Assam, West Bengal
157	*Rhacophorus lateralis* Boulenger, 1883	Kerala
158	*Rhacophorus malabaricus* Jerdon, 1870	Karnataka, Kerala
159	*Rhacophorus maximus* Günther, 1858	Arunachal Pradesh, Meghalaya, West Bengal
160	*Rhacophorus naso* Annandale, 1912	Arunachal Pradesh
161	*Rhacophorus pleurostictus* (Günther, 1864)	Kerala, Tamil Nadu
162	*Rhacophorus taeniatus* Boulenger, 1906	West Bengal
163	*Rhacophorus tuberculatus* (Anderson, 1871)	Assam, West Bengal
164	*Theloderma asper* (Boulenger, 1886)	Arunachal Pradesh
165	*Theloderma moloch* (Annandale, 1912)	Arunachal Pradesh

TABLE 1 (contd.)

GYMNOPHIONA		
ICHTHYOPHIIDAE:		
166	*Ichthyophis beddomei* Peters, 1879	Karnataka, Kerala, Tamil Nadu
167	*Ichthyophis bombayensis* Taylor, 1960	Maharashtra
168	*Ichthyophis malabarensis* Taylor, 1960	Kerala
169	*Ichthyophis peninsularis* Taylor, 1960	Kerala, Tamil Nadu
170	*Ichthyophis sikkimensis* Taylor, 1960	Sikkim, West Bengal
171	*Ichthyophis subterrestris* Taylor, 1960	Kerala, Maharashtra
172	*Ichthyophis tricolor* Annandale, 1909	Kerala
173	*Uraeotyphlus malabaricus* (Beddome, 1870)	Kerala
174	*Uraeotyphlus menoni* Annandale, 1913	Kerala
175	*Uraeotyphlus narayani* Seshachar, 1939	Kerala
176	*Uraeotyphlus oxyurus* (Duméril & Bibron, 1841)	Kerala
CAECILIIDAE:		
177	*Gegeneophis carnosus* (Beddome, 1870)	Kerala
178	*Gegeneophis fulleri* (Alcock, 1904)	Assam
179	*Gegeneophis ramaswamii* Taylor, 1964	Kerala
180	*Indotyphlus battersbyi* Taylor, 1960	Maharashtra
CAUDATA		
SALAMANDRIDAE:		
181	*Tylototriton verrucosus* Anderson, 1871	Arunachal Pradesh, Sikkim, West Bengal

more than their percentage on a world-wide basis. Twenty of the species of anurans have been described since 1970. Wherever recent intensive collecting has been carried out in India, new species of frogs and toads have been discovered, for example, at Silent Valley (Pillai 1981, Pillai and Pattabiraman 1981) and Ponmudi (Inger *et al.* 1984) in Kerala and in Meghalaya (Pillai and Chanda 1973, 1978; Yazdani and Chanda 1971). Chanda has three new species from northeastern India in manuscript (Chanda, personal communication); these are not included in our count of species, but they emphasize the point being made here. As none of these new species can be called "cryptic" or "sibling" and as only one of them belongs to a taxonomically difficult genus (*Philautus* in this case), the accretion of new forms to the faunal list is still the result of relatively coarse screening. It seems clear that further collecting, particularly in the Eastern and Western Ghats, should uncover additional new species, and that more intensive work in the Northeast should result in new Indian records of species now known only from the hilly country of Southeast Asia. Recent discovery of sibling species in such widely distributed "species" as *Rana limnocharis* (Dubois 1975) and the virtual doubling of the number of species of caecilians in the last 25 years are additional indications that one can expect the faunal list to grow significantly.

The faunal list includes eight genera not found outside India: among the caecilians, *Indotyphlus, Gegeneophis,* and *Uraeotyphlus*; among the anurans, the bufonid *Bufoides,* the microhylid *Melanobatrachus,* and the ranids *Ranixalus, Nannobatrachus* and *Nyctibatrachus.* The last two are closely related (Shaffer, in press) and, together with *Nannophrys* from Sri Lanka, probably constitute a single, distinctively Indian, ranid radiation. In addition to *Melanobatrachus,* the microhylid genera *Ramanella* (with 6 species in India and 2 in Sri Lanka) and *Uperodon* (with one of its two species occurring in Sri Lanka as well as in India) represent at least one additional Indian radiation; the uncertainty arises because, despite an excellent monograph on the Microhylidae (Parker 1934), phylogenetic relationships within the family are obscure. The ranid genus *Micrixalus* has most of its species in India. Indeed, Pillai (1978) has suggested that only the species from India and Sri Lanka are congeneric. At the very least, the Indian species of *Micrixalus* constitute another regional radiation. The recently described *Ranixalus* appears to us, on the basis of the original diagnosis and description (Dubois 1985), to be closely related to *Micrixalus* and part of the same radiation. The caecilian genera are members of two families and, therefore, represent at least two more Indian radiations.

Additional evidence for the distinctiveness of the Indian amphibian fauna comes from the four most speciose anuran genera, *Bufo, Rana, Philautus,* and *Rhacophorus,* and the largest caecilian genus, *Ichthyophis,* all of which have wide distributions outside of India. Species of these four anuran genera account for 106 of the 165 species of frogs and toads occurring in India, and of those 106, 61 are restricted to India. If we add in those species whose ranges do not extend beyond the territories immediately adjacent to India, i.e., Sri Lanka, Pakistan, Nepal, and Bangladesh, endemism in these four anuran genera increases to 77%. All seven of the Indian species of *Ichthyophis* are restricted to the territory of India. Turning the picture around, we find only 23% of 181 species of Indian amphibians occur beyond the fringes of India as far as China, Burma, or Southwestern Asia.

GEOGRAPHIC DISTRIBUTION WITHIN INDIA

The abundance of species of amphibians is very uneven across India. The highest concentrations of species and genera are in the Northeast and in the Western Ghats of the West Peninsular region (Table 2). As endemic species constitute 62% of the Indian fauna, it is not surprising that the distribution of endemics is also uneven: 84 of the endemics are found only in the Western Ghats and 20 only in the Northeast region. The magnitude of the disparity between the two areas of highest diversity and the others shown in the table is partly a reflection of very unequal collecting intensity. This effect seems especially apparent in the case of the Eastern Ghats (included in the East Peninsular region of Table 2); the semi-deciduous forests that still exist there in patches should provide good habitats for a number of species. Yet no endemic arboreal anuran has been recorded from the ghats in Orissa or Andhra Pradesh. However, given the long known association between amphibian diversity and perhumid environments (for an Asian example, see Inger 1980) we expect the regional disparity shown in the table to remain large, for the Northeast and the Western Ghats are the areas of heaviest precipitation in India. The high diversity regions are also those that until relatively recently had large areas of tropical evergreen forests, structurally complex environments providing the maximum number of microhabitats. The interaction between forest environments and diversity is clearly seen when the proportions of bush and tree dwelling frogs in the fauna of the Northeast (32%) and Western Ghats (29%) are compared to the proportions (<13%) in the other regions.

A small group of anuran species accounts for much of the overlap between regions: *Bufo melanostictus, Microhyla ornata, Rana cyanophlyctis, R. limnocharis, R. tigerina,* and *Polypedates maculatus.* These species live in close association with man wherever they occur

Table 2

Distribution of Indian amphibians by regions. The climates of the Indian regions as defined here are: Northwest—temperate, montane; West—arid to semiarid; Deccan—hot, monsoonal; Ganges-Brahmaputra Valley—humid, hot, monsoonal; East Peninsular—monsoonal, humid in areas; Northeast—humid, to subtropical to tropical, montane; West Peninsular—humid tropical, partly montane.

Region	States included	Order	Genera	Species	Species code*
Northwest	Jammu & Kashmir Himachal Pradesh Punjab Uttar Pradesh (part)	Anura	9	21	5, 17-8, 22, 24, 34, 43-5, 56, 72, 78, 93-4, 98, 106, 111, 113-4, 116, 152
West	Gujarat Rajasthan	Anura	5	9	18, 34, 78, 85, 90, 94, 111, 116, 152
Deccan	Madhya Pradesh Andhra Pradesh (part) Bihar (part) Karnataka (part) Maharashtra (part) Tamil Nadu (part)	Anura	7	18	13, 18, 22, 41-2, 75, 76, 78, 85, 90, 94, 96, 111, 116-7, 120, 150, 152
Ganges-Brahmaputra Valley	Uttar Pradesh (part) Bihar (part) Assam (part) West Bengal (part)	Anura	9	18	18, 22, 29, 34-5, 41-3, 64, 76, 78, 85, 94, 108, 111, 116, 120, 152
East Peninsular	Orissa Andhra Pradesh (part) Tamil Nadu (part)	Anura	8	21	13, 18, 22, 34-5, 41-3, 76, 78, 85, 94, 101, 107-8, 111, 116, 117, 120, 150, 161
Northeast	Arunachal Pradesh Bhutan Manipur Meghalaya Sikkim Assam (part) West Bengal (part)	Anura	16	53	1-4, 6, 9, 14, 18, 23, 25-6, 28, 31, 34, 44-7, 65, 67-8, 71-2, 78-9, 82-3, 88-9, 92-5, 97, 105, 111, 122-4, 129, 134, 137, 145, 151, 153, 155-6, 159-60, 162-5
		Gymnophiona	2	2	170, 178
		Caudata	1	1	181
West Peninsular	Kerala Maharashtra (part) Karnataka (part) Tamil Nadu (part)	Anura	17	99	7-8, 10-1, 13, 15-6, 18-22, 27, 29-30, 34-43, 48-55, 57-63, 69, 70, 73-4, 76-8, 80, 85-7, 90-1, 94, 96, 99, 101-4, 107, 109-12, 115-21, 125-8, 130-3, 135-6, 138-44, 146-50, 152, 154, 157-8, 161
		Gymnophiona	4	13	166-9, 171-7, 179-80

* Species code = numbers preceding species names in Table 1.

and all but the last range far beyond the borders of India. Removal of these ubiquitous commensals of mankind from the regional lists eliminates or greatly reduces overlap among regions. In fact, without these six weed-like species, there remain only five significant overlaps (i.e., 7 or more species in common to two regions) among regional faunas: both Deccan and Ganges-Brahmaputra faunas with the East and West Peninsular faunas and between the East and West Peninsular faunas. The known overlaps among regional faunas, with the six commensals of man removed, are accounted for largely by a set of seven other species that burrow and live in open fields: *Bufo stomaticus, Uperodon globulosus, U. systoma, Rana crassa, Tomopterna breviceps, T. dobsoni,* and *T. rolandae.* The only exceptional overlap is that between Northeast and Northwest faunas, which involves four swift-water breeders typical of mountainous areas: *Rana blanfordi, R. liebigi,* and two species of *Amolops.* Thus, virtually all of the similarity among regions, considering all species of amphibians, is accounted for by species of anurans that can tolerate conditions created by man's activities.

The most distinctive regional faunas are the two largest, the Northeast and the West Peninsular. Pillai and Chanda (1976) recorded the species known at the time from the Northeast and Chanda has a thorough review of this fauna in ms. As would be expected, in the Northeast one finds the largest concentration of species whose ranges are mainly Southeast Asian or Burman-Chinese, 28 of 56 species. In the West Peninsular, as already noted, the largest number of endemics occurs. All Indian caecilians are confined to these two areas of high diversity, 2 of the genera and 13 of 15 species being restricted to the West Peninsular region. Intensive collecting and observation in the near future will almost certainly increase the number of endemics known from the East Peninsular, Deccan, and Ganges regions, but it is unlikely that the numbers will ever approach that in the West Peninsular area.

Beyond the changes in overlap between Indian regions, additional collecting and reporting will clarify the ranges of many species that have obviously imperfectly known distributions. As examples, we need only cite the ranges of *Uperodon systoma, Rana beddomii, R. crassa, R. malabarica,* and *R. syhadrensis* (see Table 1) each of which has a gap that appears to be an artifact resulting from imperfect knowledge rather than a significant biological phenomenon.

Despite the present weaknesses in the faunal lists of large areas and in the known ranges of individual species, it is clear that Indian amphibian species constitute three distributional types: (1) species confined to the Western Ghats, the largest unit; (2) species known in India only from the Northeast; and (3) a set of essentially ubiquitous species that comprise the bulk of the known fauna in all of the territory between the Western Ghats and the Northeast.

COMPARISON WITH FAUNAS OF OTHER REGIONS

Although the Indian amphibian fauna has a number of endemic genera and many endemic species, it does share species with adjacent areas (see above). Most of these shared species occur in Burma (33 anurans, 1 salamander) and somewhat fewer in Sri Lanka (21 species of anurans) and Nepal (16 anurans, 1 salamander). These relations are what one would expect given the relative sizes of the adjacent faunas and the nature of environments at the borders. Twenty-one species are shared with China, but all except

5 of them also are known from Burma. None of the Indian caecilians is known from outside the country.

Compared to anuran faunas to the east, the Indian fauna seems to have high proportions of frogs of the families Ranidae and Rhacophoridae and low proportions of Pelobatidae and Microhylidae (Table 3). However, applying an arcsin test of the proportion of species in each family in the Indian fauna against the corresponding proportion in each of the other faunas yields only one statistically significant difference: that between the proportions of ranid species in the Indian and Bornean faunas (t=3.40, P=0.001). Therefore, in terms of distribution of species of anurans in families, the Indian fauna does not differ importantly from the Southeastern faunas.

Table 3

Comparison of Indian amphibian fauna with those of other Oriental areas. Sources for areas other than India

Family	India			Thailand			Yunnan			Borneo		
	Number of gen.*	Number of spp.**	% of spp.	Number of gen.	Number of spp.	% of spp.	Number of gen.	Number of spp.	% of spp.	Number of gen.	Number of spp.	% of spp.
ANURA	27	165		22	86		18	60		26	122	
Discoglossidae							1	2	3.3	1	1	0.8
Pelobatidae	3	6	3.6	2	11	12.8	3	11	18.3	3	11	9.0
Hylidae	1	1	0.6	1	1	1.2	1	1	1.7			
Bufonidae	4	21	12.7	4	7	8.1	1	2	3.3	6	28	23.0
Microhylidae	5	15	9.1	5	13	15.1	4	9	15.0	7	20	16.4
Ranidae	8	77	46.7	4	37	43.0	4	23	38.3	5	34	27.9
Rhacophoridae	6	45	27.3	6	17	19.8	4	12	20.0	4	28	23.0
GYMNOPHIONA	4	15		1	4		1	1		2	5	
Caeciliidae	2	4										
Ichthyophiidae	2	11		1	4		1	1		2	5	

Sources: Anura=Thailand—Taylor, 1962. Yunnan—Zool. Inst. Sichuan, 1977. Borneo—Inger, 1966; Inger & Frogner, 1979; Inger & Gritis, 1983; Dring, 1983a &b; Kiew, 1984a, 1984b; Matsui, 1986. Gymnophiona=Frost, 1985.

* Genera.

** Species.

Diversity of the Indian anuran fauna at the species level appears to be higher than in the other Asian faunas (Table 3). The difference may be due to the wide geographic separation of the two largest Indian subregional faunas, which has clearly resulted in two separate areas of speciation, and the juxtaposition of one of them to a rich, external source (Burma) of additional species. Diversity of Indian anurans in terms of genera does not differ significantly from the other Asian faunas (Table 3).

India clearly has a larger and generically more diverse caecilian fauna than the other areas (Table 3). As observed earlier, this high diversity is concentrated almost entirely in the Western Ghats.

CONCLUSION

The following points seem evident to us:

(1) That the Indian amphibian fauna as a whole is quite distinct, having endemic genera of ranid and microhylid frogs and caecilians, and a large number of endemic species of several wide-spread Oriental genera — *Bufo, Rana, Philautus,* and *Ichthyophis.*

(2) That there are only two Indian areas of known high endemism, the Northeast and the West Peninsular (which includes the Western Ghats).

(3) That the Indian fauna is divisible into three groups of species: those known only from the Northeast, those known only from the Western Ghats, and a small group of ubiquitous species.

(4) That as expected the regions abutting other continental areas, that is, the Northwest and Northeast, show the highest levels of non-Indian species.

(5) That the actual geographic distributions of many Indian species are very poorly known and, therefore, that knowledge of the faunas of several Indian regions is very weak.

(6) That additional intensive collecting and observation will certainly result in the discovery of new species as well as improvement in our understanding of distribution of the fauna.

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AN EXPERIENCE OF WILDLIFE PHOTOGRAPHY

M. Y. Ghorpade[1]

(*With fourteen plates*)

As I have said in my book "Sunlight & Shadows" — An Indian Wildlife Photographer's Diary: "A good wildlife photograph conveys directly the joy and beauty of nature. It can make us happy, which, in the ultimate analysis, is the main motive force for any real transformation of attitudes and sincere sustained action", in any field including the vital area of nature conservation. "I consciously chose the medium of black-and-white photography for its relative permanence compared to colour, and the scope it gives for artistic expression — the delicate play of light and shade to softly delineate texture and mood". I do hope these photographs reflect the joy of nature, the excitement of wildlife observation and photography, and the great need to conserve our rich flora and fauna.

The best way to convey to the reader how photographs can be taken is to perhaps faithfully describe how some of these photographs were actually taken. There are so many favourable factors which have to come together to make a good photograph but one has to be constantly and correctly aware of the nature of the opportunity in terms of photographic values and lighting. It is the total effect that one has to keep on visualising in the midst of fleeting moments and changing scenes. Ultimately much depends on how we react, which in turn depends on some kind of total awareness and harmony between ones inner and outer environment at a given moment of time. A good wildlife photograph is never made to order. The element of chance or luck is always there, in the sense that one rarely has complete control over the opportunity, which sometimes lasts only for a split second. To know the nature and behaviour of the film and the camera is only the first step, though an important and unavoidable one. But after that one has to concentrate on picture taking which is not just technique but an adventure and an experience.

One of my earlier photographs is that of a Hanuman monkey or langur (*Presbytis entellus*), (Plate 1, Fig. 1), racing up and down at top speed, leaping from pillar to pillar along my old fashioned compound wall at Shivapur (my residence at Sandur, in the Bellary district of Karnataka). With a 35 mm single lens reflex camera having a shutter speed of 1/1000th of a second (which could be used in the lighting because of the fast 400 ASA TRI-X film I had loaded), I positioned myself at a spot from where, without causing much alarm to the monkey, I could take a picture at right angles, as the langur leapt into the air. In anticipation of the monkey repeating its exhuberant run along the line of pillars, I focussed at a pre-determined spot and waited. Sure enough the monkey, true to its nature, came hurtling at top speed and I pressed the trigger as his hind legs were about to leave the focussed spot. It was as though the speed and rhythm of this fast action had triggered my reflexes and the index finger which did its work with hair-breadth precision and timing. I got the monkey in mid-air, his long tail imitating the undulating Sandur hills beyond. This is a photograph which depends on its animation and split-second timing. One other langur photograph which I took years later was in the forests of Kanha, the subdued light percolating softly through the foliage, making it possible to show detail in the black faces of two langurs sitting on a low rock with a charming expression and catch-light in their eyes (Plate 1, Fig. 2). This is a photograph which depends heavily on correct lighting, exposure and development. If I had managed to click a split-second earlier, I could have got three langurs in a row, which might have been a more impressive photograph; the third langur could also have spoilt the picture by doing something at the nick of time which was not in consonance with the harmony and balance of the picture as a whole. The pleasing photograph of two sambar does and a stag (Plate 3, Fig. 3) in evening pictorial light was taken at Ranthambhore which is a gem of a sanctuary.

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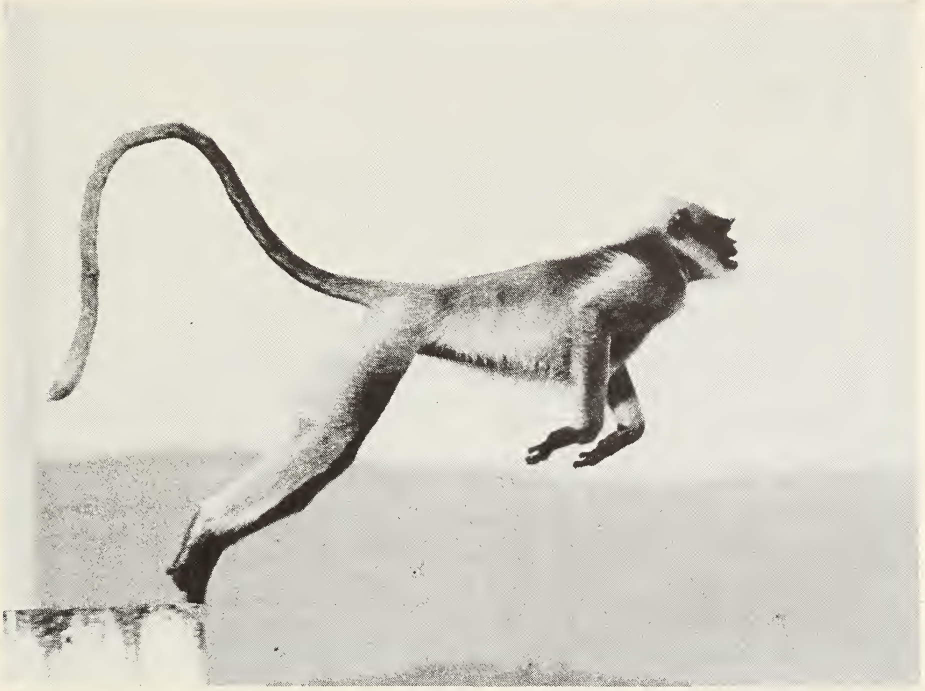
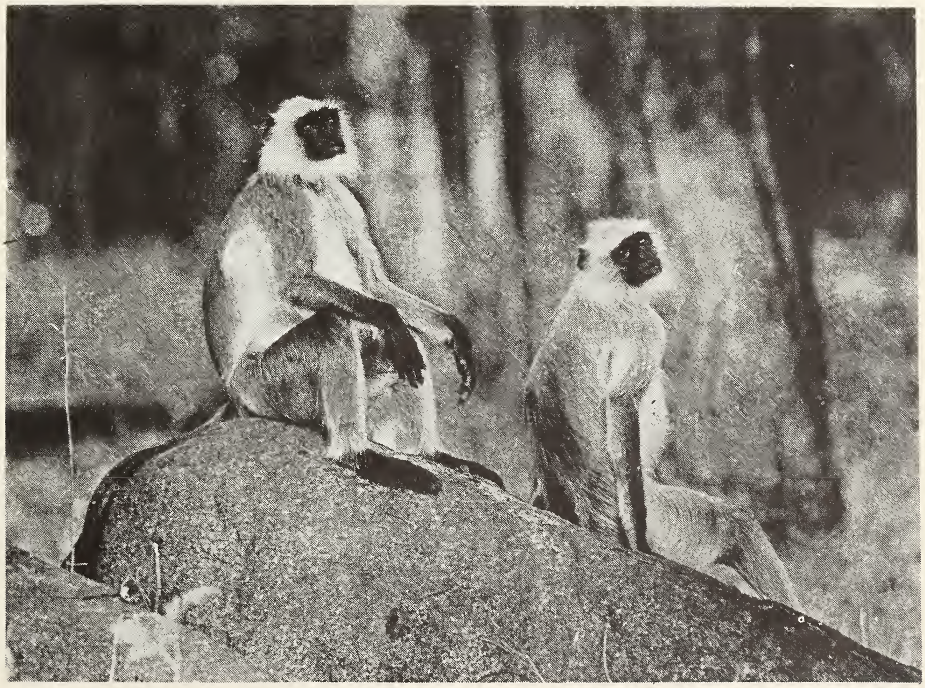
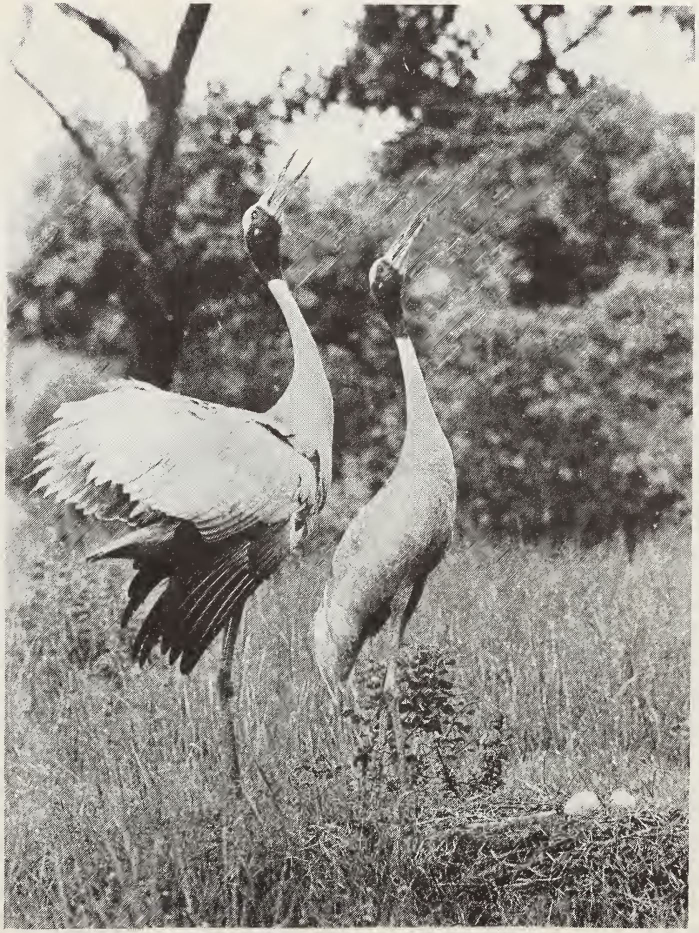
A great deal depends on responding quickly to an above average opportunity. The element of chance is also very much there. Once when my jeep had got stuck in the slush of a Bandipur forest road in a downpour, a tusker came along the same road and started rubbing himself in the natural shower, giving me an opportunity to experiment with shutter speeds to try and get a photograph in which the elephant would be sharp though seen through a translucent curtain of rain (Plate 2, Fig. 4). This is one of my favourite photographs. In the same forest I once photographed a magnificent tusker surrounded by a herd of female elephants (Plate 3, Fig. 5) trying to guard him with all their might and heavy devotion. I managed to get a photograph filling the ideal format frame before an irate female close to the tusker decided to chase me to a safer distance. In this photograph all the animals form a photogenic group and there is a broad spectrum of animation and life. The photograph tells its own story and can be blown up easily to a size of 40″ × 60″ without any serious loss of definition. The photograph of elephant mothers and aunts scrubbing their babies was taken at Periyar, also with the bigger negative (Plate 4, Fig. 6). It depends for its appeal on the rare subject interest inspite of the harsh top lighting. A part of this large herd moving away into the forest, with their bodies glistening ebony-wet after a cleansing swim across the river, was pictorially caught to convey the atmosphere and the movement (Plate 4, Fig. 7).

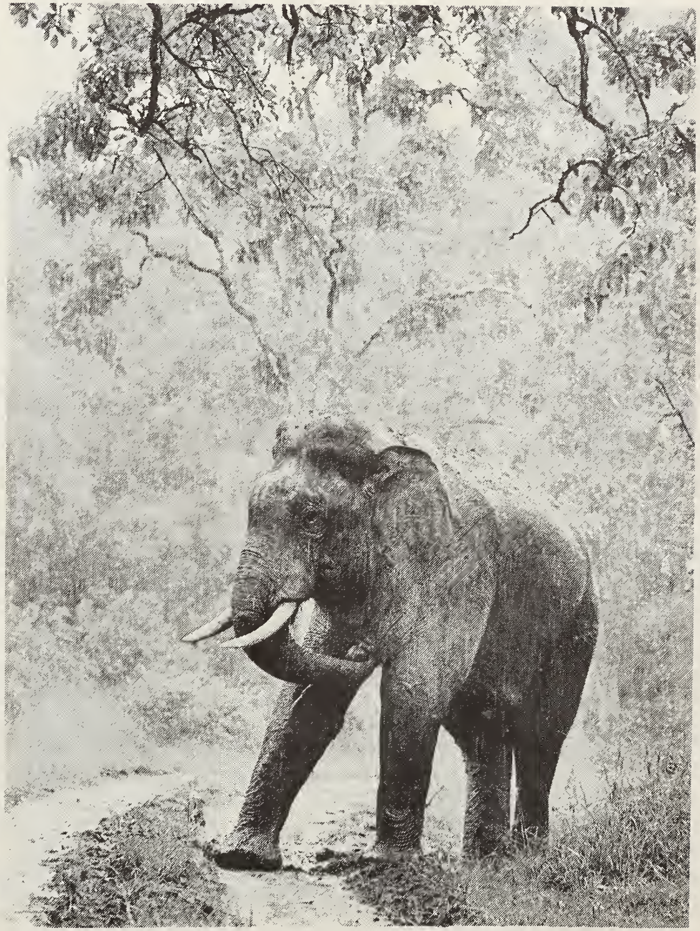
It has always been an exciting experience to photograph tigers in broad daylight from fairly close distances, to try and fill the square negative of my Hasselblad camera, using the appropriate tele lens. However, the photograph of the snarling tigress was taken with a 6×7 Pentax SLR camera and a 200 mm lens, from an open jeep, at a distance of exactly eight metres. I had sat motionless in the jeep for nearly an hour before the tigress got up from the heavy grass and walked straight towards the jeep. Just then the sun had gone behind a cloud making the light ideal for photography. I clicked when the tigress was looking straight at me; she snarled and I clicked again (Plate 5, Fig. 8). I got my pictures. The experience of taking these photographs had made an unforgettable impression on me which the photograph may not succeed in conveying, in all its nuances, to another person who is only looking at the photograph. The tiger on the rock and the tiger in the pool were taken from a riding elephant which is always a tricky business, as one can never be sure of





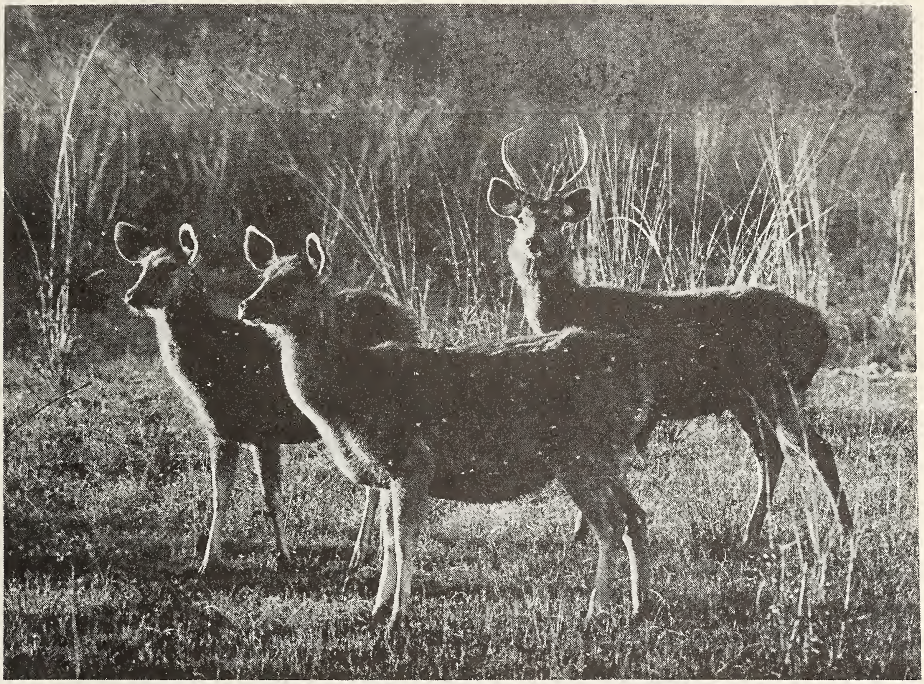
Above: Fig. 1. Hanuman's leap. *Below*: Fig. 2. Two langurs on a rock.
(*Photos*: M. Y. Ghorpade)

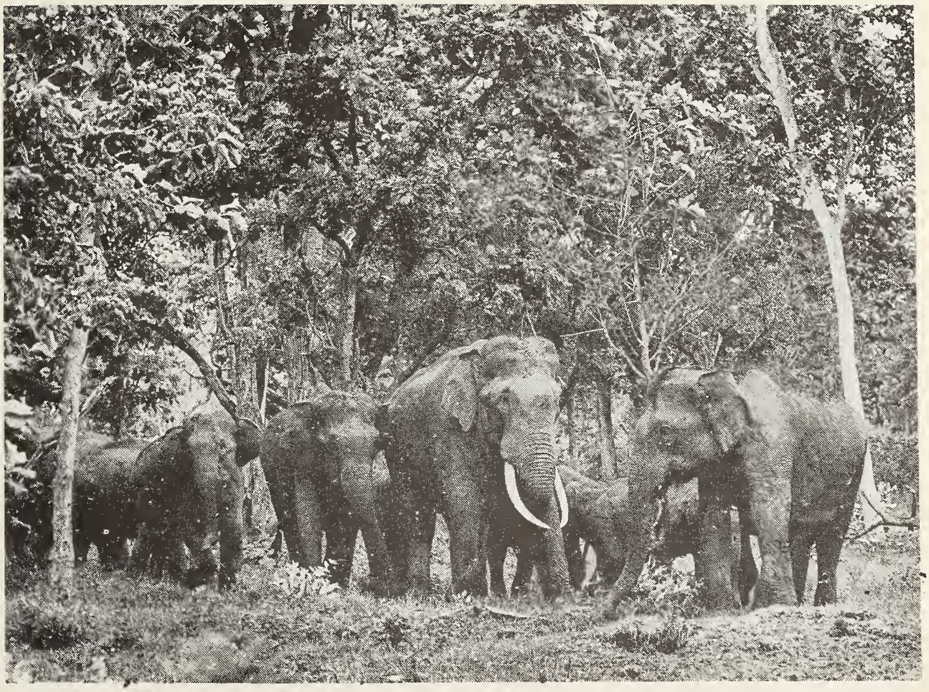




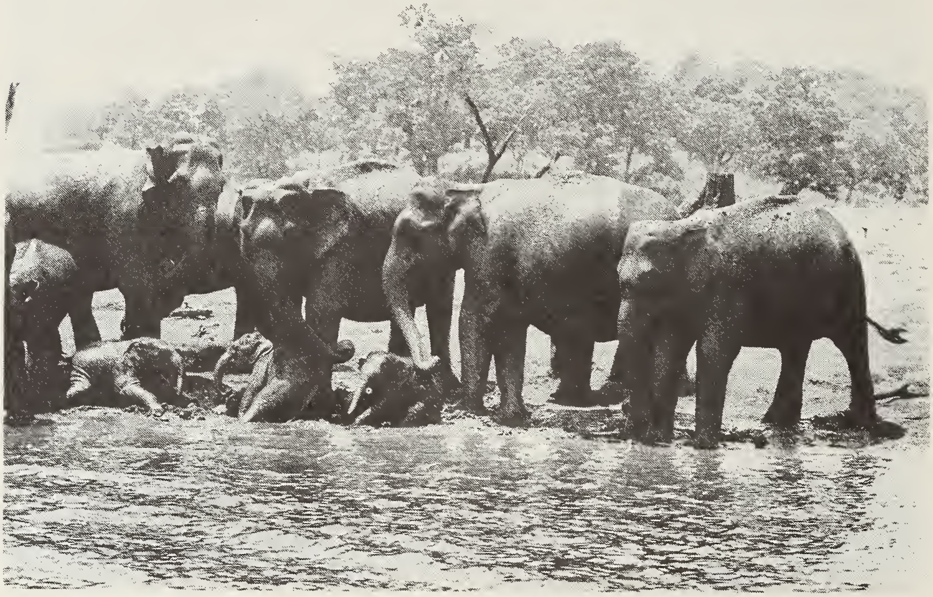
Left: Fig. 27. Sarus cranes in greeting display. *Right*: Fig. 4. Tusker in the rain.

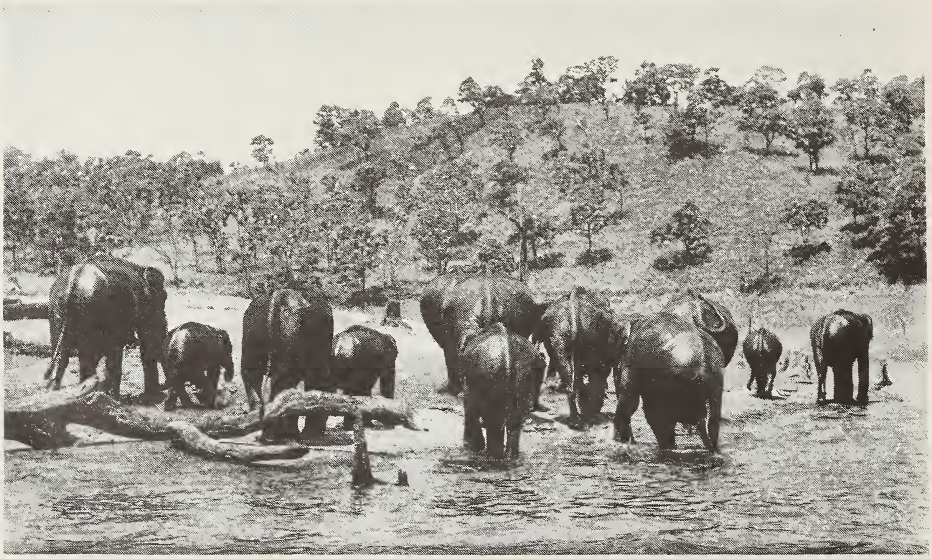
(*Photos*: M. Y. Ghorpade)



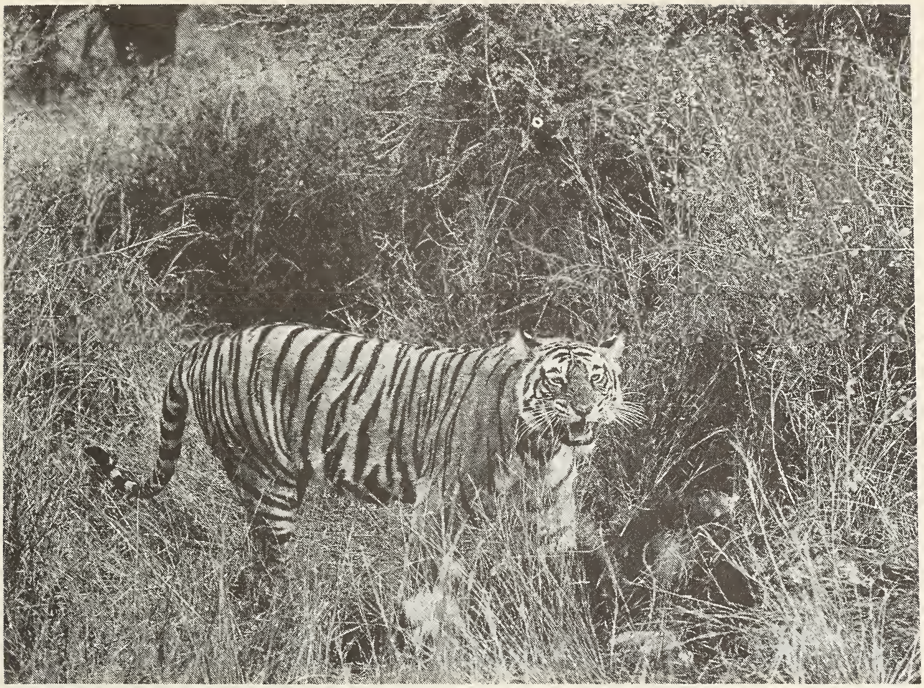


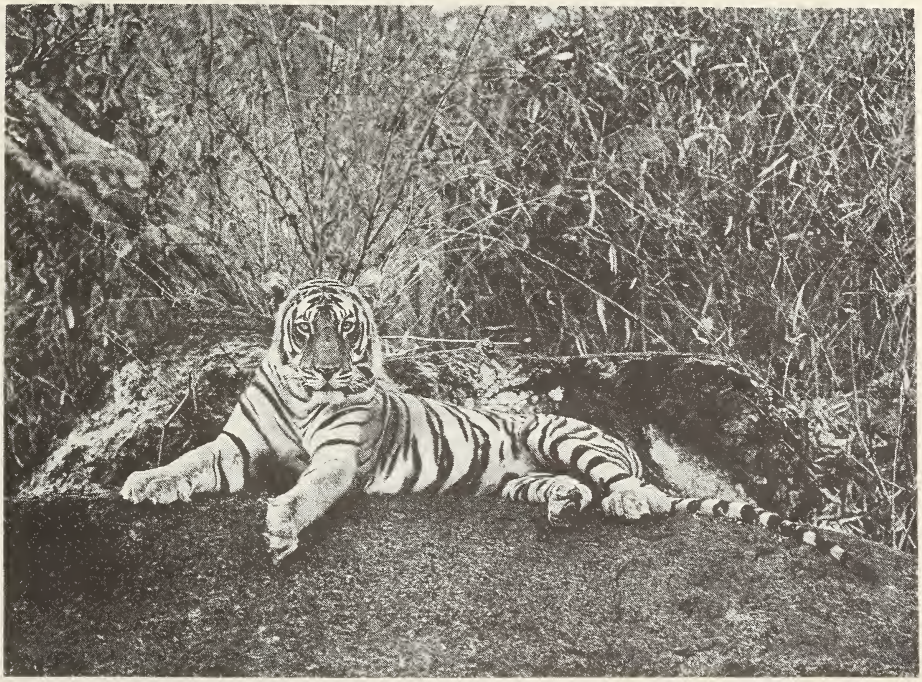
Above: Fig. 3. Sambar in pictorial evening light. *Below*: Fig. 5. A tusker and elephant herd at Bandipur.
(*Photos*: M. Y. Ghorpade)



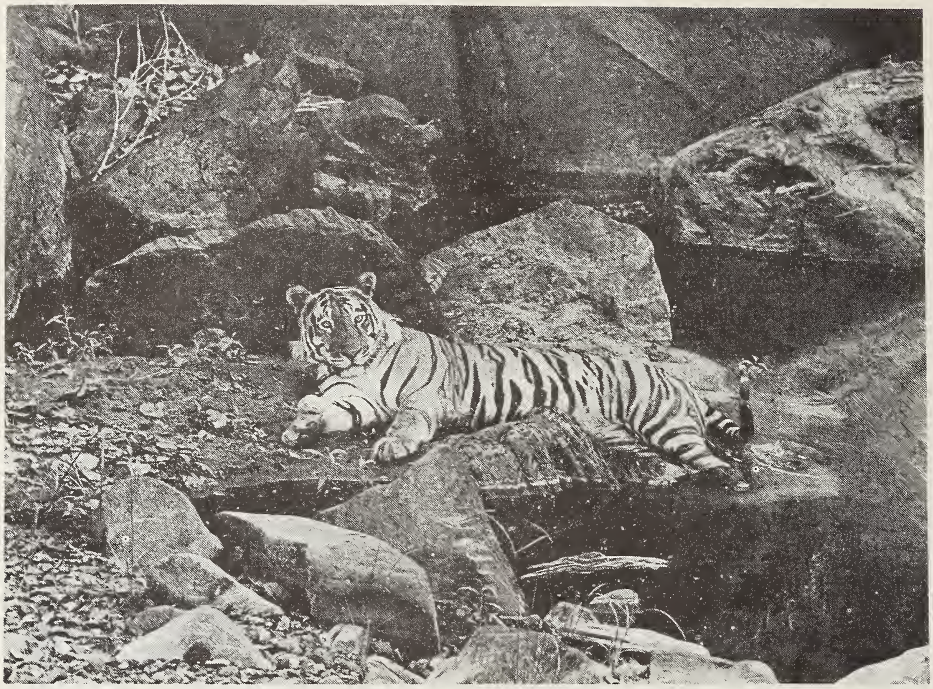


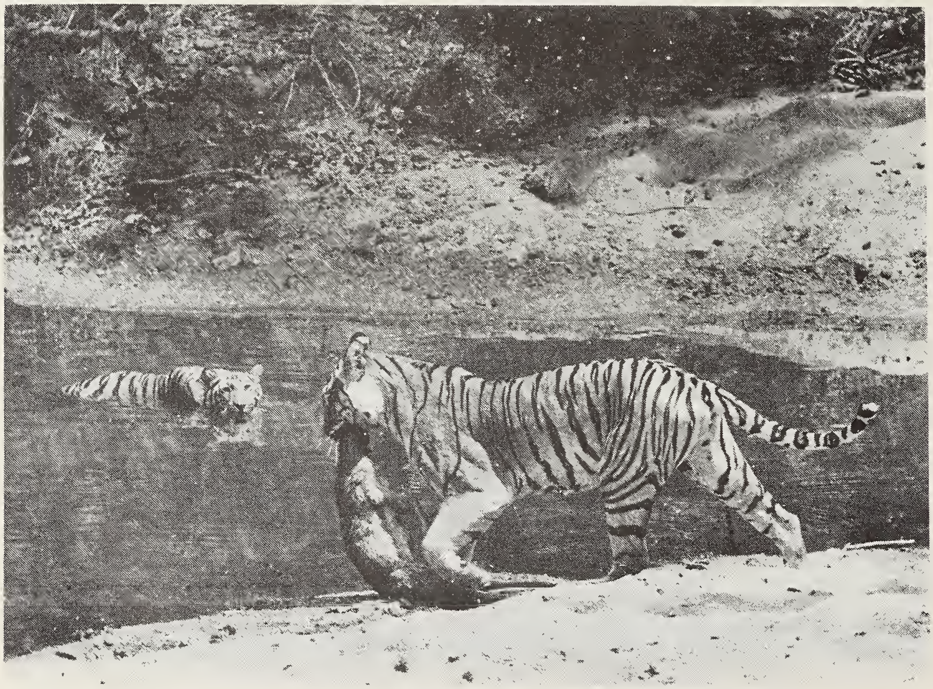
Above: Fig. 6. Mother elephants scrubbing babies. *Below*: Fig. 7. Elephant herd after a swim.
(*Photos*: M. Y. Ghorpade)



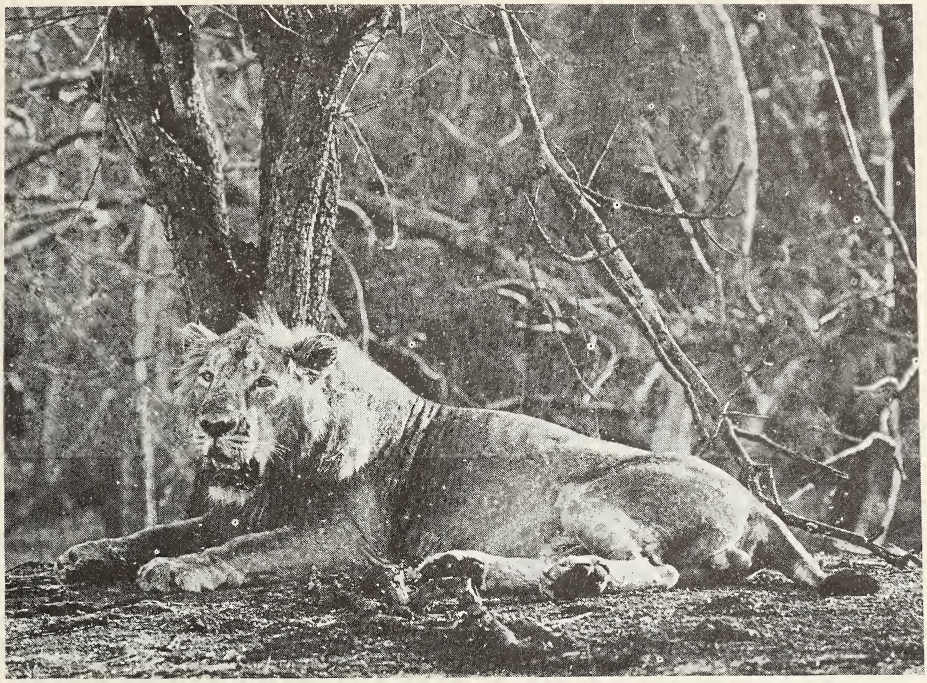


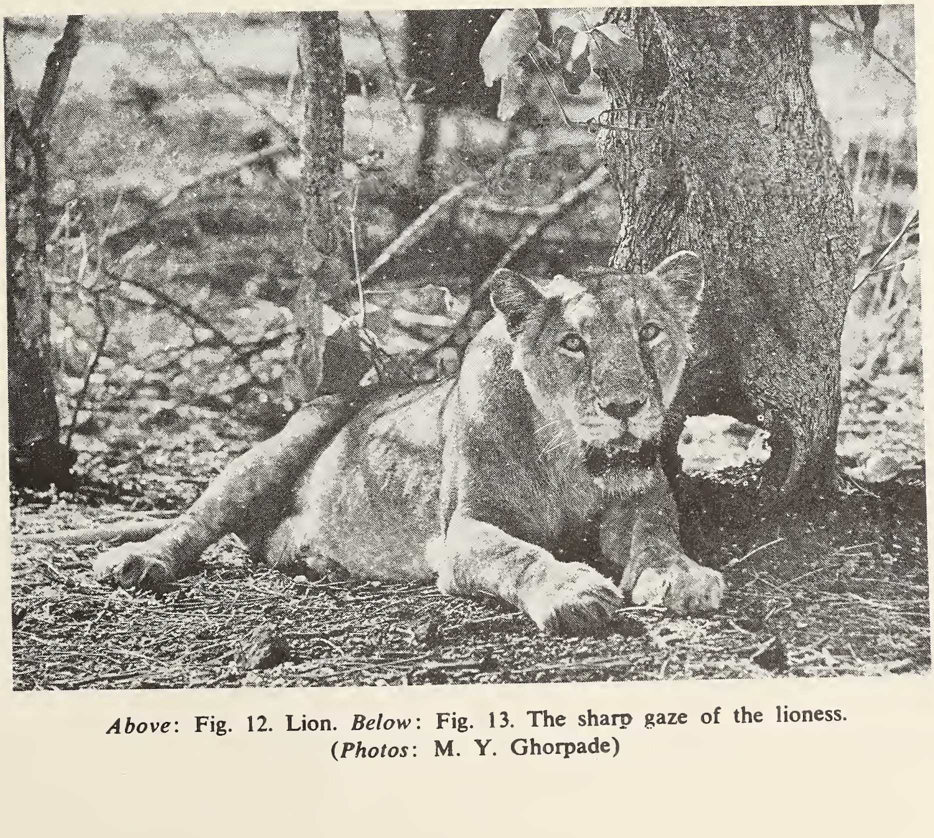
Above: Fig. 8. Snarling tigress. *Below*: Fig. 9. Tiger on the rock.
(*Photos*: M. Y. Ghorpade)



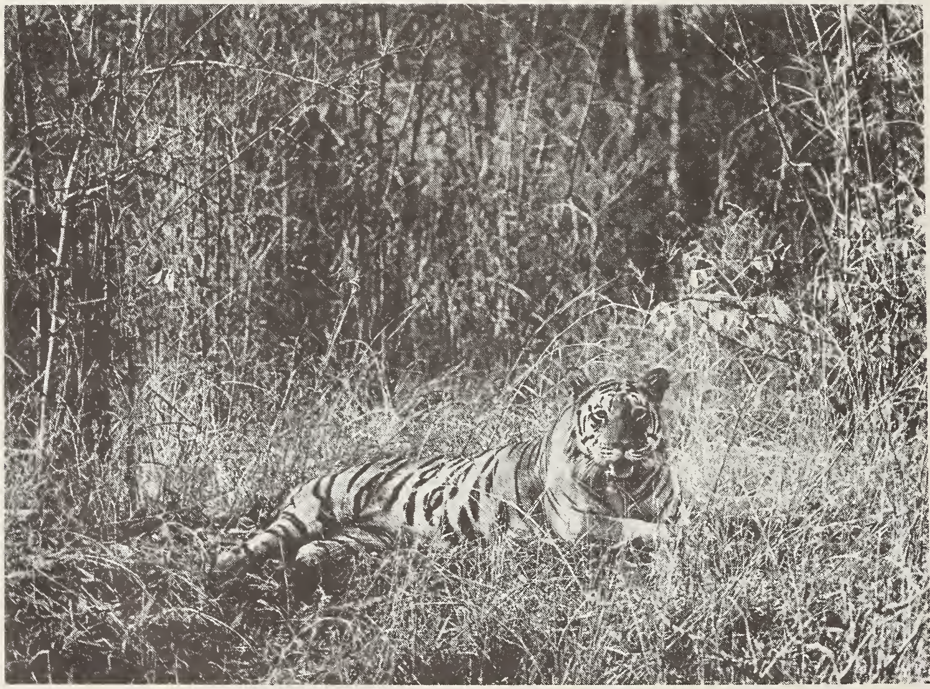


Above: Fig. 10. Tiger in the pool. (*Photo*: M. Y. Ghorpade)
Below: Fig. 11. Tigers with a natural kill. (*Photo*: Ajai M. Ghorpade)

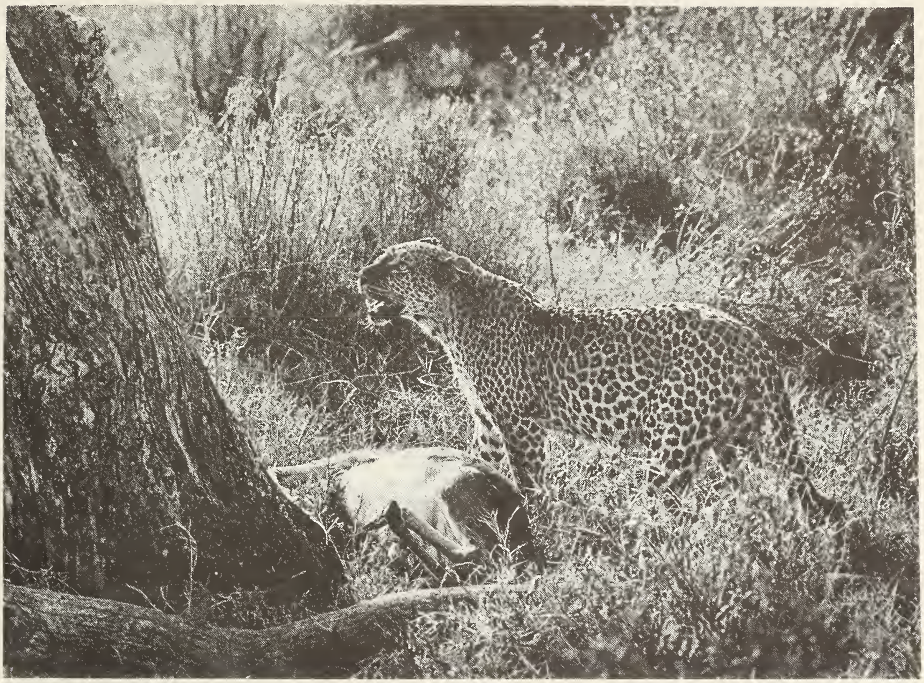


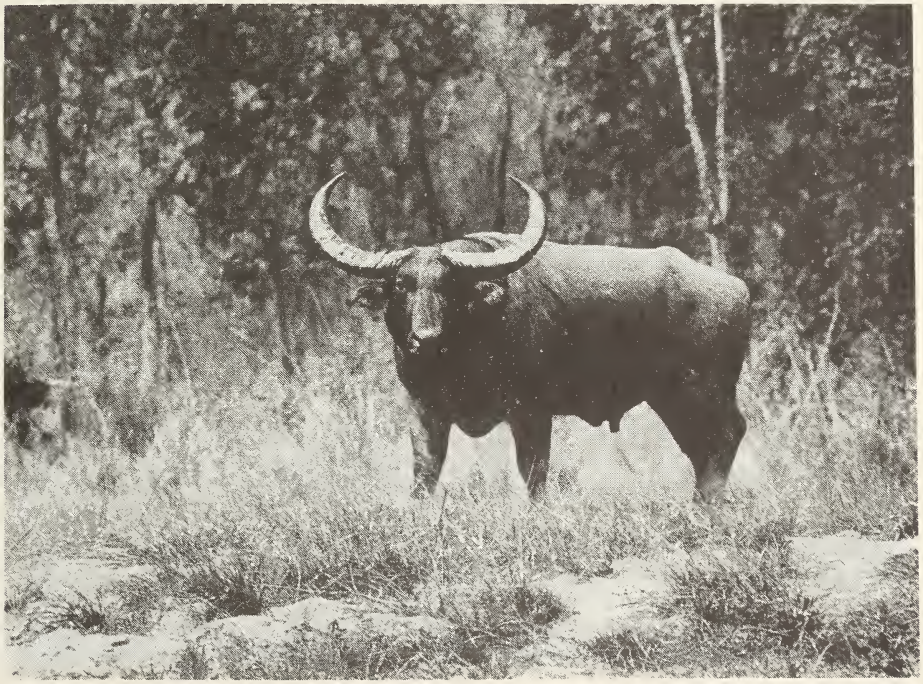


Above: Fig. 12. Lion. *Below*: Fig. 13. The sharp gaze of the lioness.
(*Photos*: M. Y. Ghorpade)

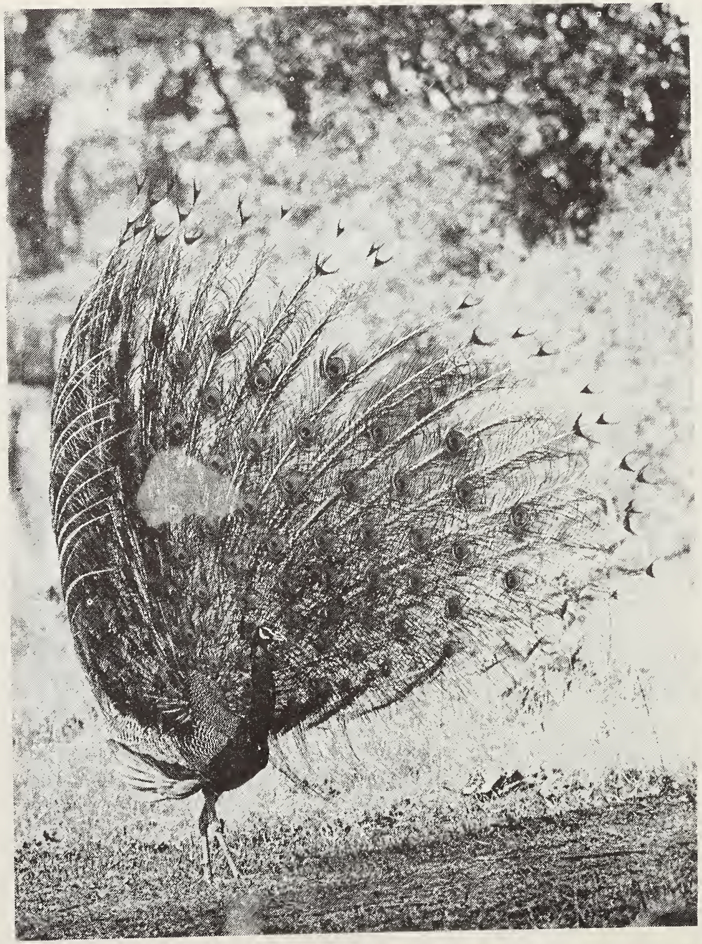


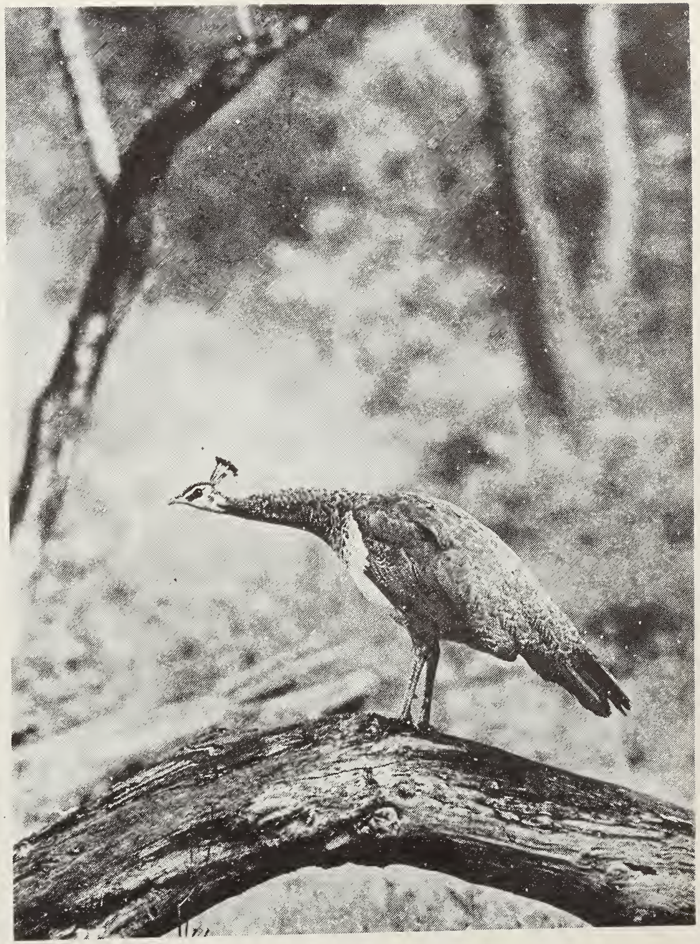
Above: Fig. 14. Tiger staring. *Below*: Fig. 15. Big tiger at Kanha Kisli.
(*Photos*: M. Y. Ghorpade)



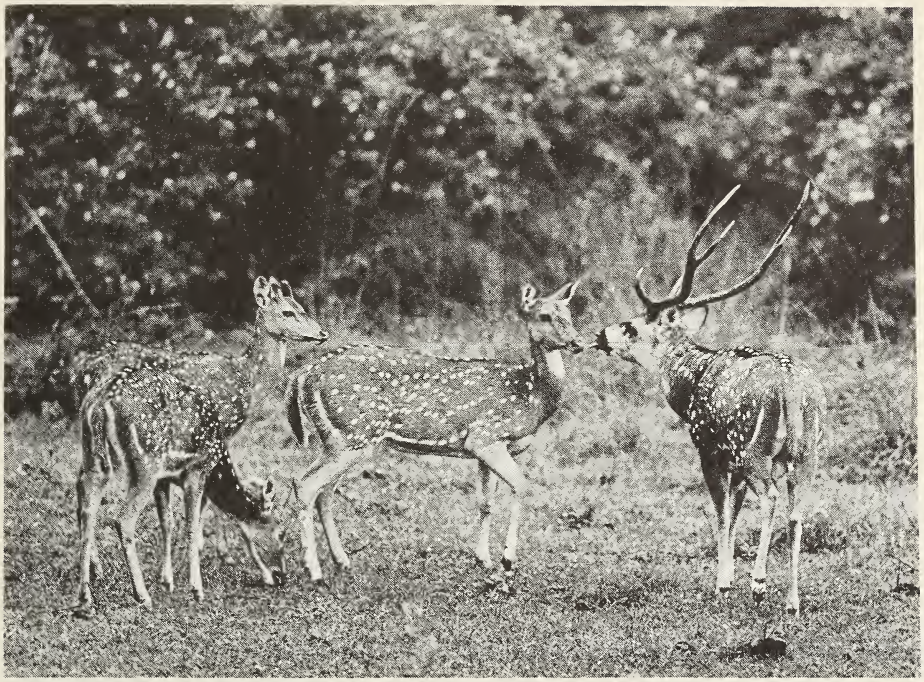


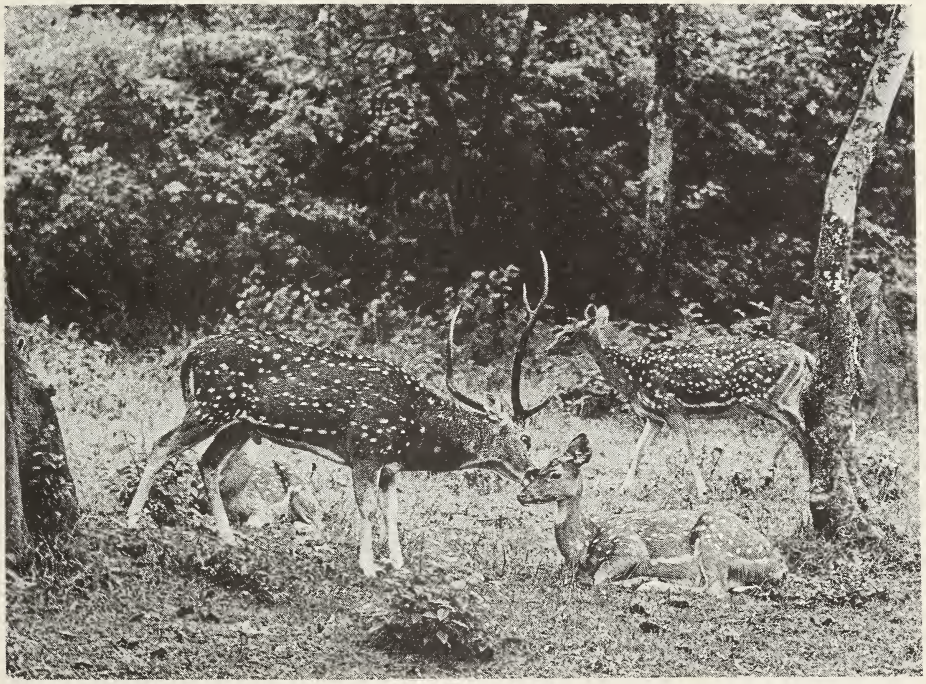
Above: Fig. 16. African leopard. *Below*: Fig. 22. Wild buffalo bull (Manas).
(*Photos*: M. Y. Ghorpade)



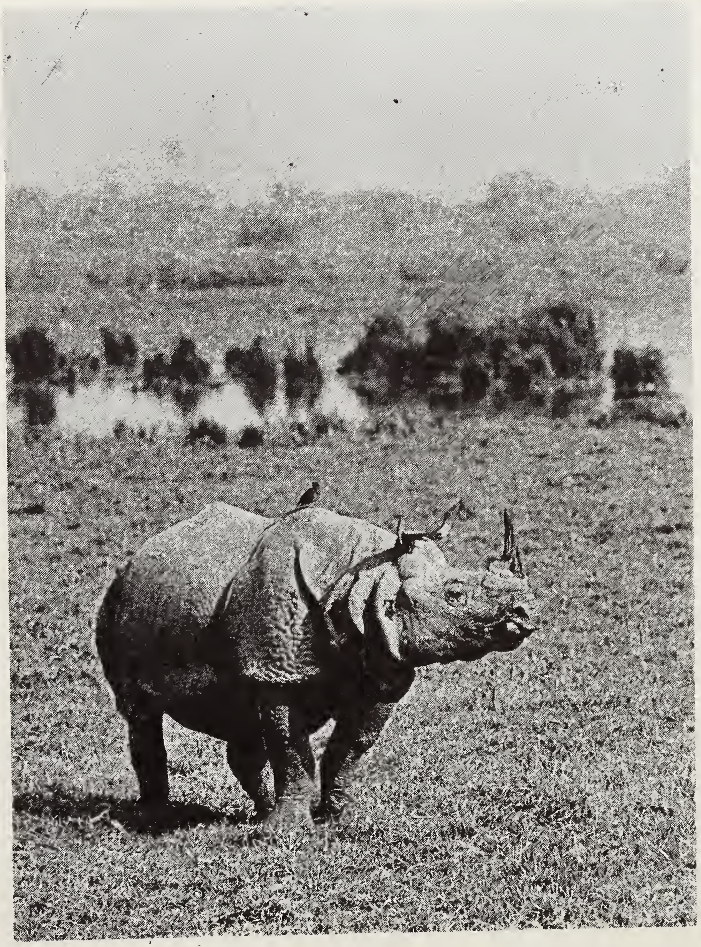


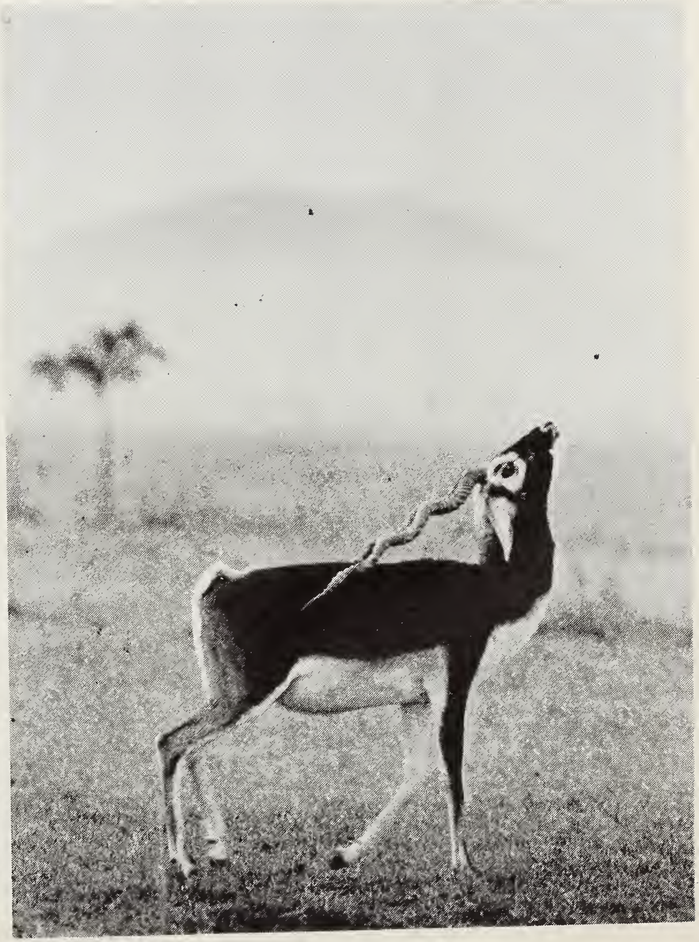
Left: Fig. 17. Peacock dancing. *Right*: Fig. 18. Peahen.
(*Photos*: M. Y. Ghorpade)



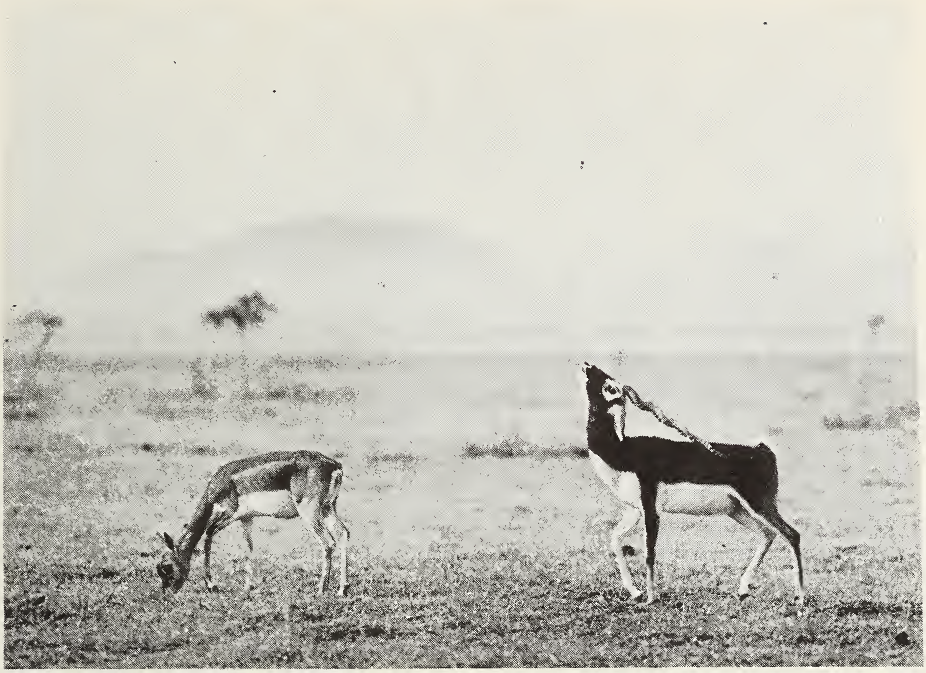


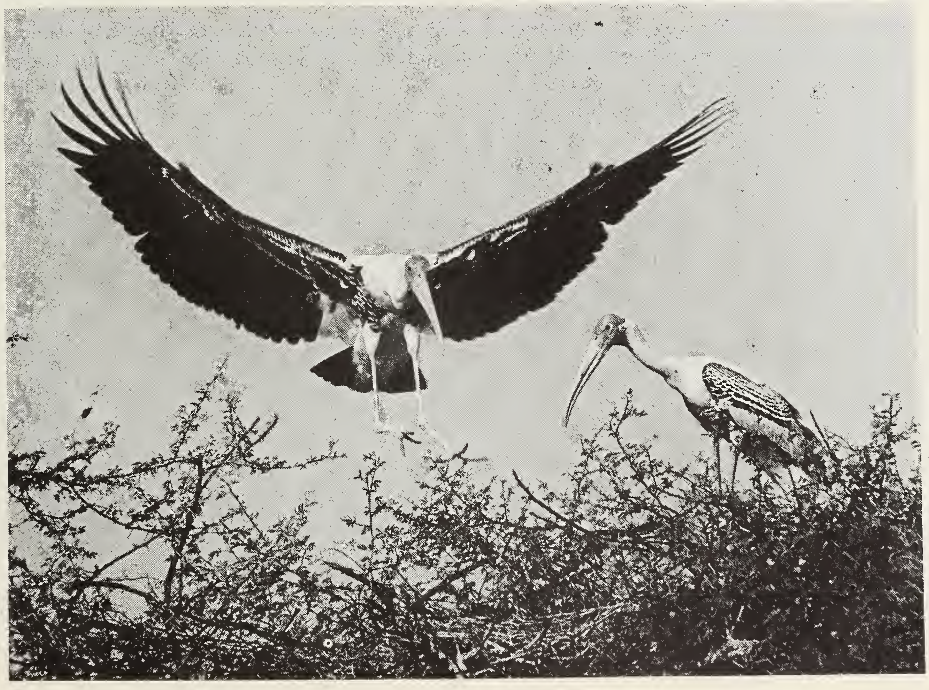
Above: Fig. 19. Loving and lovable chital. *Below*: Fig. 20. Stag kissing doe.
(*Photos*: M. Y. Ghorpade)





Left: Fig. 21. Big Bull rhino. *Right*: Fig. 24. Blackbuck.
(*Photos*: M. Y. Ghorpade)





Above: Fig. 23. Blackbuck and doe. *Below*: Fig. 26. Painted stork alighting on nest.
(*Photos*: M. Y. Ghorpade)

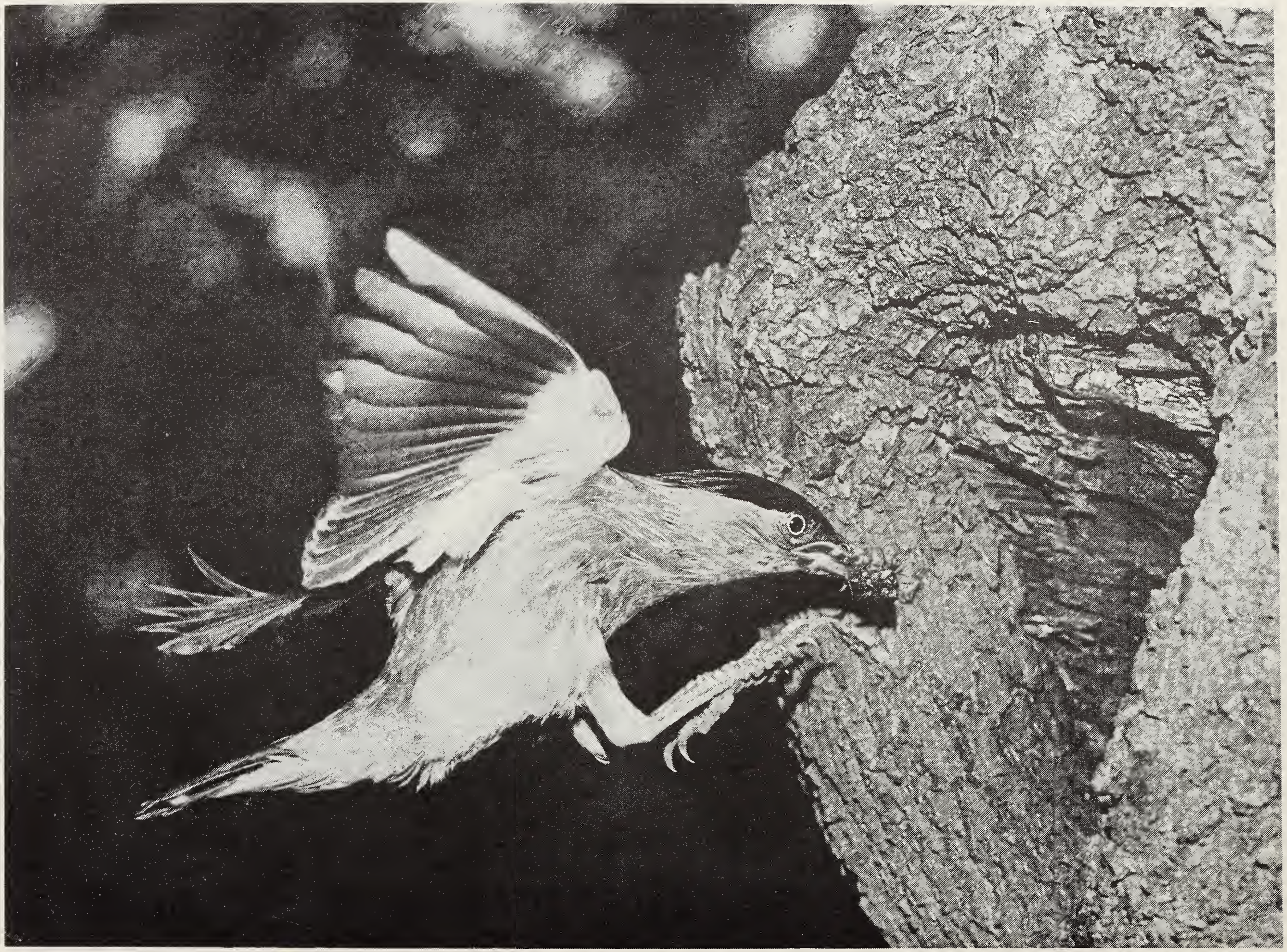


Fig. 25. Brahminy mynah.
(*Photo*: M. Y. Ghorpade)

getting a shake free picture from an elephant which is never perfectly still. One has to carefully choose the moment to click and try and operate the shutter at not less than 1/250th of a second. Fast film definitely helps as the problem of minimal shake is more serious than is generally realised, and shows up badly when one makes big enlargements. Apart from the elephant's breathing, awareness of ones own breathing is important in getting shake free pictures. It helps to empty ones lungs and then hold the breath at the time of releasing the shutter, which has to be as smooth as possible. The tiger on the rock is a picture of perfect confidence and power, his relaxed front paws with half-exposed claws symbolising strength which could go into action any time (Plate 5, Fig. 9). The mood of the tiger in the pool is reflected in his eyes, half-raised head, alert ears and the tail which has been lifted from the pool in a question mark, water dripping from its tip like a tap (Plate 6, Fig. 10).

It was also at Kanha that I once witnessed a tiger cub make a natural kill and then wait in the pool for his mother, the tigress, to walk towards him with the kill held firmly in her more experienced mouth. The two played in water for a long time. It was a unique opportunity and, as the tigress walked across the sandy river bed towards her cub crouching in shallow water, I clicked away from elephant back along with my son, Ajai, who timed his shot and got this rare wildlife photograph with the Hasselblad and the 250 mm Sonnar lens from a distance of about 20 metres. I had in my hand the other Hasselblad camera with the 150 mm lens. The swift action and the excitement did not permit changing of lenses at the last minute. But Ajai made no mistake. The picture is perfectly composed and records a rare experience (Plate 6, Fig. 11).

At Gir, locating lions was not a problem, nor going close enough to them. But getting a very good photograph was still not so simple. After going after lions for days, and taking a number of photographs whenever it was possible to do so, I got a picture which satisfied me — a male lion in soft majestic light (Plate 7, Fig. 12). I started photographing the lion, on foot, from a distance of about 30 metres with my Hasselblad 250 mm lens, slowly approaching to about 10 metres of this lordly animal, when I used my 150 mm lens to include enough of the forest background and get enough depth. I stood leaning against a convenient tree and clicked whenever the light picked up the features of the beast, pleasingly. I could clearly see the light brown pattern in his eyes. On another occasion I was able to capture the deep concentration and mesmeric sharpness in the eyes of a lioness (Plate 7, Fig. 13), from very close at ground level. At Kanha I got a picture of a tiger staring at me with the same sharpness and perhaps a little more anger (Plate 8, Fig. 14). The big male tiger at Kanha Kisli (Plate 8, Fig. 15), panting in the heat with his mouth open was taken at a distance of about 15 metres with my Hasselblad and 250 mm lens, which is ideal in such a situation. Under Indian conditions a 350 mm lens is also extremely useful to fill the frame without trying to get closer to the animal than the critical distance. To know by experience and pay enough attention to the critical distance is very important in wildlife photography, to maximise one's chances of getting good results without disturbing the animal concerned. Much also depends on what the animal has experienced and the conditions in a given area or situation. This is where wildlife photography is not merely a question of knowing ones camera and other accessories but the behaviour pattern and mood of the animals being photographed. Close observation is the very essence of successful wildlife photography which only freezes a particular moment for ones own continued pleasure and for posterity. Wildlife photography in India is generally far more challenging than in Africa where the equatorial light is remarkably shadow free and animals are mostly roaming in the open. This photograph of the leopard (Fig. 9, Fig. 16), which is no different to the Indian one, was taken in the Serengeti National Park of Africa.

It is amazing how easy it is to take photographs of chital or spotted deer at the Bandipur National Park in Karnataka. But it is not so easy to get an outstanding photograph of even the chital which is such a common and undisturbed animal in these parts. A photograph as a record and as an aesthetic achievement serves two purposes which if combined results in a pleasing wildlife photograph. Photographs of the Peacock (Plate 10, Fig. 17) and the Peahen (Plate 10, Fig. 18) were taken at Bandipur, the latter with a Hasselblad 500 mm lens, throwing the background out of focus. The loving and lovable chital (Plate 11, Fig. 19) and the stag kissing doe (Plate 11, Fig. 20) are two pictures which portray a soft mood in soft light. In the former, the young male has shot out the tip of his tongue towards an inquisitive doe, in a sudden gesture of affection, which would have been impossible to record if I had not been continuously watching the animals through the camera lens, ready to click any moment. Taking pictures from the hatch in the roof of my jeep-van makes for greater freedom, support and stability. Wildlife photography is a continuous process of learning and adaption to field conditions, the nature and temperament of different species, and the mood of a particular animal in a given situation. At Kaziranga, I succeeded in photographing an impressive male specimen of the Great Indian one-horned rhinoceros (*Rhinoceros unicornis*), from almost ground level, by making my riding elephant sit down while I took my picture (Plate 12, Fig. 21). Next time, a different Rhino whose mood I had misjudged did not permit the same stable strategy and came snorting at my riding elephant which managed to get up on all fours just in time. At the Manas Wildlife Sanctuary I managed to photograph a good specimen of a wild buffalo bull (*Bubalus bubalis*) resting my Hasselblad 500 mm lens on a tree which was lying across an open patch of land (Plate 9, Fig. 22). I am sure if it were not for this tree, the buffalo, which defiantly stood his ground, would not have allowed me to get away with it. One has always to be careful and never take wild animals for granted. That often proves a fatal error. Wildlife photography is not meant to endanger either the photographer or the photographed. As I have said in Sunlight & Shadows: "There is always a certain amount of risk in wildlife photography, especially when one has to get close enough to take a picture; but a combination of ignorance and arrogance can be fatal".

The Blackbuck (Krishnasara in Sanskrit) is a typically Indian antelope eulogised in our classical literature but now an endangered species in its own land. The grace and elegance of the blackbuck has to be seen to be believed and yet many sophisticated persons have never seen a blackbuck in the wild or know what it looks like. Only photography can now bring the animal within the visual reach of the many, both in the urban and the rural areas. Here are photographs of a blackbuck and doe (Plate 13, Fig. 23) and a single blackbuck strutting about with his handsome head held high and horns slanting backwards and downwards, forming a romantic triangle with the horizontal back-line and the perpendicular neck and chin pointing proudly to the skies (Plate 12, Fig. 24). Kalidasa highlights the loving grace of the blackbuck in his Kumarasambhava and Shakuntala. Must the romance of the blackbuck come to an end? If it does, a beautiful aspect of the soul of India would have perished for ever. It is the purpose of wildlife photography to make us aware of our natural heritage and make us want to preserve it with all our heart and soul.

Finally a word about bird photography. I have done nest-site photography with an electronic flash and have been able to arrest birds in flight with fairly simple equipment, as in the case of the brahminy or black-headed mynah returning to its nest in a tree hole to feed its young (Plate 14, Fig. 25). But what I have enjoyed more is to take pictures of birds in the open in natural light. The Bharatpur bird sanctuary provides excellent opportunities for such work. The painted stork alighting on its nest (Plate 13, Fig. 26) made a good picture but what gave me supreme satisfaction was to photograph a pair of sarus cranes (Plate 2, Fig. 27), from a hide, with my Hasselblad EL and the 500 mm lens mounted on a tripod. After hours of patient waiting I got a perfect opportunity to capture the birds in the ecstasy of action when they "suddenly indulged in a beautiful greeting display, their heads pointing to the heavens, beaks partly open and eyelids fluttering in a spontaneous expression of joy and conjugal bliss. They were happy to be happy". The time was 8.45 a.m. A thin cloud covered the face of the sun, reducing its harshness without affecting very much its light value. I could give an exposure of f8 and 1/250th of a second with a fast 400 ASA ORWO film, rated by me at 320 ASA, to suit my well tried exposure development technique using Microdol-X (1:3 dilution). I have done most of my wildlife photography with this film mainly for reasons of availability. Wildlife photography is much more than just equipment and materials. It is essentially a way of looking at nature and its denizens with a kind of sensitivity and response which is a part of ones innate personality.

AUTOMIMICRY AND BATESIAN MIMICRY IN UROPELTID SNAKES: PIGMENT PATTERN, PROPORTIONS, AND BEHAVIOR

Carl Gans[1]

(*With two colour plates*)

INTRODUCTION

The 35 species of the snake family Uropeltidae, endemic to southwestern India and Sri Lanka, are burrowers that appear to be most closely related to members of the genus *Cylindrophis* (Daniel 1983, De Silva 1980, Gans 1966, 1976; Mahendra 1983, Rajendran 1986). Uropeltids have cool-temperature thermal preferenda, modified burrowing method and musculature, friction resistant skin and a short, blunt tail capped with a spinous caudal cap, from which the family derives its name (Gans 1974, 1976). The burrowing pattern permits them to move deeply into tropical soils, utilizing their more-or-less pointed head and the ability to throw the neck into a series of S curves for penetration and widening tunnels amid roots and rock particles. The majority of the uropeltids show a variety of bright contrasting colors along the sides of their trunk, generally of shades of orange and red offset with black; also they display a curious constricting behavior whenever they are dug up.

Over the last fifteen years, I have worked at obtaining an understanding of the distribution and biology of these animals. The methodology consisted of collecting systematically, initially in Sri Lanka. We first visited localities from which specimens had been deposited in museums or reported in the literature. We then tried to collect in intermediate localities to see whether the species occurred there and whether disparate forms were connected by morphologically intermediate variants. Also, we worked around the periphery of known ranges in order to document these more carefully. Finally, we worked through regions for which no specimens had been reported previously and visited localities and biotopes that had not previously been sampled to see what forms might occur there.

In the wet forest areas, our collecting proved relatively simple because I could, after some time, identify microhabitat situations in which particular species were taken with substantial frequency. However, for dry and low-land areas, it was best to rely on the advice of local people for the initial information. Toward this end, we would stop along the road and in small hamlets, there to talk to farm workers, local agriculturalists, road construction people, school teachers and their students. A diversity of specimens, sealed in plastic or glass tubes, was, in each case, displayed to them, as we found that verbal descriptions of what was and was not to be found in a particular area were much improved when one or more actual specimens were at hand. These served as a refresher of memory and refined the descriptions by people who had seen the species earlier. We then distributed preservation materials as well as prefranked and numbered postcards, permitting simple notifi-

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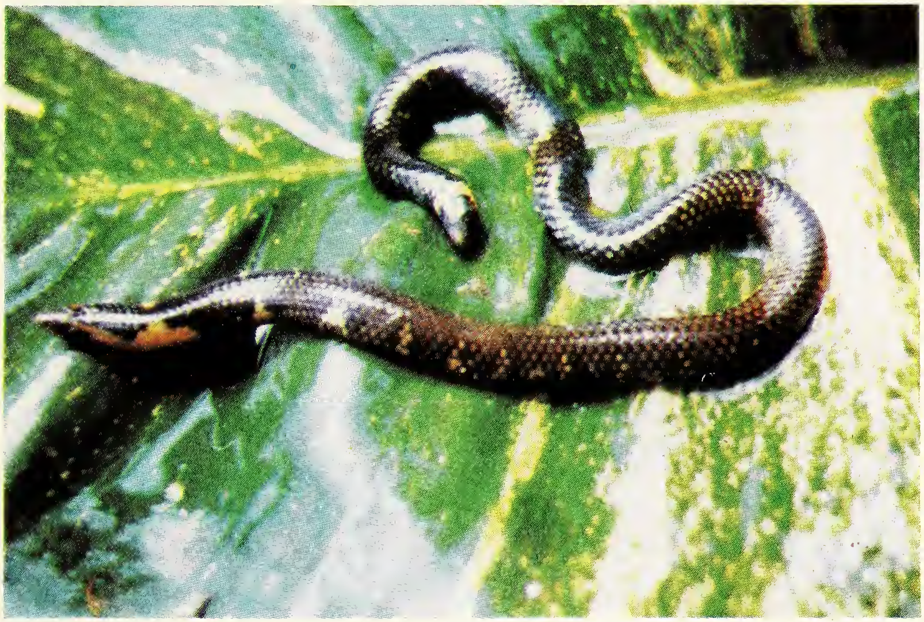
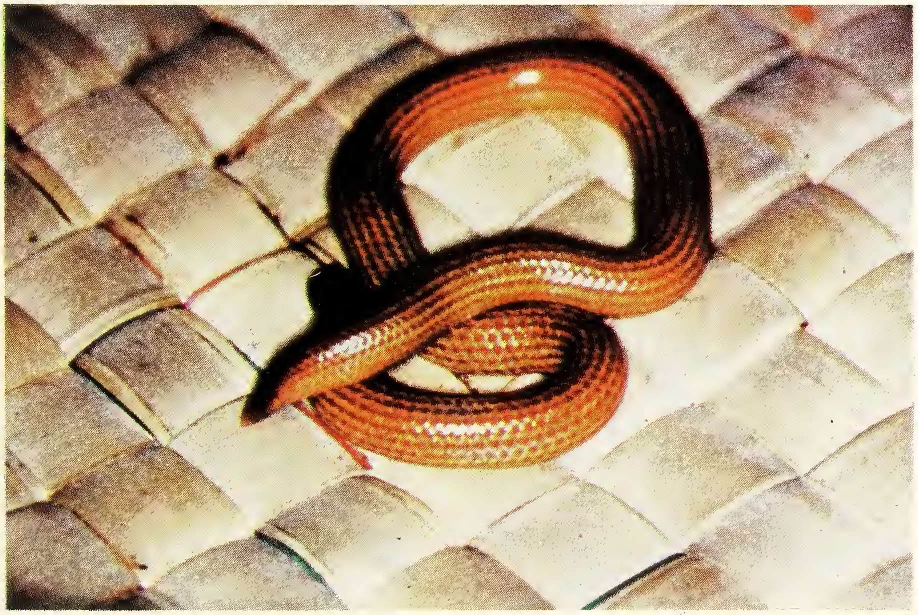
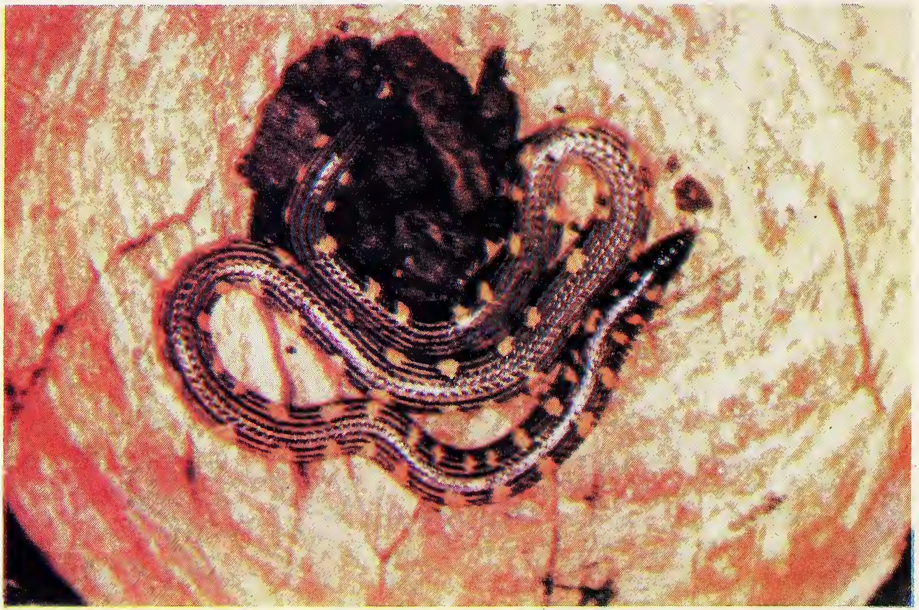
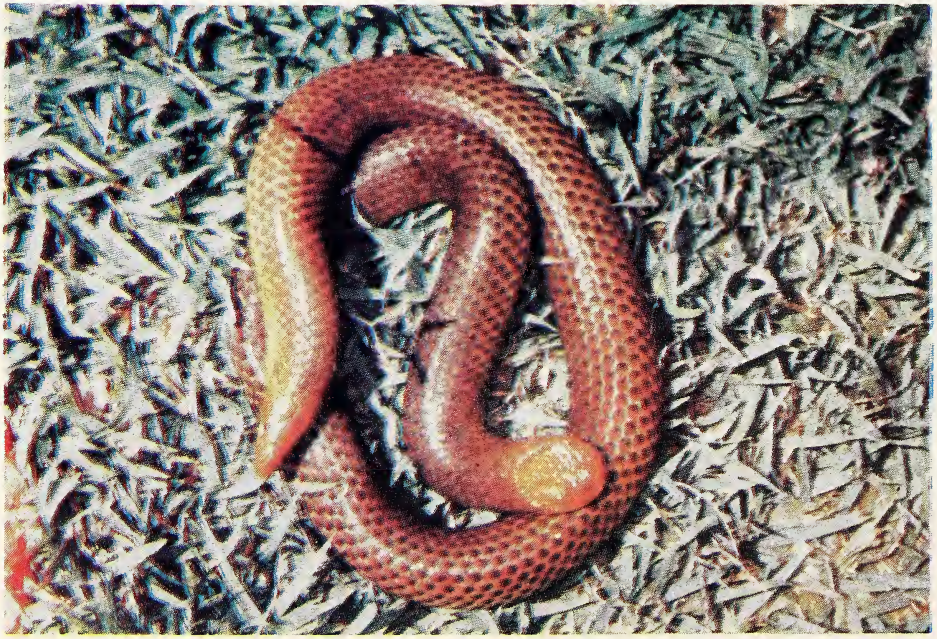




Above: *Rhinophis blythi.* Below: *Rhinophis drummondhayi.*
(*Photos*: Author)





Above: *Uropeltis phillipsi.* Below: *Pseudotyphlops philippinus.*
(*Photos*: Author)

cation once the rains had come and specimens had been obtained.

Whereas the project was not fully completed, we did obtain enough material for a marked refinement of distributional and altitudinal maps, for some biochemical studies and for the characterization of new species. It is hoped that the reports on these will be ready for publication in the not too far distant future. Also, the work allowed us to develop some general treatments in discussing the Sri Lankan species and their biology.

GENERAL DEFENSIVE PATTERN

Analysis of some of the characteristics mentioned in the original species diagnoses and incidental natural history notes indicate that these characteristics confer some level of protection against predation encountered in the tunnels. The nature of such defenses is constrained by the nature of the burrowing mechanism. As this is concentrated in the head and anterior 20 per cent of the animal's trunk, the remainder lacks strong muscles, so that these species cannot dig backward and are only capable of slight reversing movements. The vulnerability of the posterior end is reduced by the caudal cap. This is not only reinforced interiorly and overlain by heavy covering keratin, but the spines and ridges cause dirt particles to be wedged into place. These in turn cohere with other bits of soil, forming a cap of mud that follows the animal down the tunnel. Whereas we still lack statistically evaluable data for predator prey interactions, it is interesting that uropeltids found in the stomach of various burrowing snakes, such as *Cylindrophis* and *Bungarus,* always have been swallowed head first. The defense represented by the caudal cap then succeeds as often as 50 per cent of encounters.

Whereas deeply burrowing snakes should but rarely encounter visually hunting animals, uropeltids show some aspects that conflict with this remark. The three factors are general crypsis, head-tail mimicry and Batesian mimicry.

The first observation is that a number of uropeltid species show an overall coloration that matches the color of the soil in which they live. Thus, the yellowish *Rhinophis punctatus* lives in zones of yellow sand, the more orange tinted *R. dorsimaculatus* in lenses of more reddish sands, whereas the black *R. oxyrhynchus, R. philippinus* and *R. trevelyanus* mainly occupy very dark soils. Such cryptic matching of the background color is otherwise concentrated to species occupying open areas and has there been shown to reflect defense against sight-hunting predators (Greene, in press; Pough, in press).

The second characteristic suggesting that sight hunters are an important component in the life of some uropeltids is the general tendency to head-tail mimicry. It could be argued that the blunt form of the tail is due to the in-tunnel defense mechanism, and that the slender termination of the head and neck reflects the specialized tunnel-forming methods. Indeed it is quite clear that these biological roles establish and maintain the major phenotypic pattern, which in this sense represents a morphological constraint. However, several major considerations argue for the effect of surface predation. The first is a behavioral one, in that uropeltids always hide the head and display the tail. The head tends to hide under the coils and will engage in active movement into soil, forming or entering existing tunnels, while the tail is simultaneously waved about. The second is that the coloration enhances the illusion. The caudal cap is often distinctly marked, both laterally and ventrally, so that the image of a head with eye spots appears obviously expressed as the tail is lifted and waved about during disturbance. In contrast, the head markings break up the outline of the anterior end. In *Rhinophis blythi*, there is a lateral band around the head that crosses the oculars and gives the impression in dorsal view that the head is slimmer and shorter. In *R. punctatus* a middorsal V of darkened pigment emphasizes the slender caudal end.

The third aspect relates to the lateral markings on the trunk. Whereas the dorsal surface is generally unicolored (except for that of the spectacular *Uropeltis phillipsi*), these lateral markings are expressed in sharply defined patches of strongly contrasting colors, solid whites, yellows and oranges. The intermediate zones tend to be as dark or darker than the dorsal surface. Certainly, these lateral markings cannot be seen as cryptic; however, they may represent startle marks, displayed only after the animal has been discovered by a predator. On the other hand, they can be interpreted as Batesian mimicry of some of the many species of yellow and black banded centipedes that are commonly encountered sympatrically with uropeltids. Some of these have a poisonous bite.

Theoretical considerations indicated that the dupe in the system would likely be one of several species of fowl, endemic throughout the range in which the uropeltids occur. They meet the conditions that the dupe should be a predator which shared the biotope, which was common enough there to represent a substantial threat (thus justifying the cost of protection) and which could recognize the signal being mimicked. Jungle fowl, spur fowl and pea fowl occur on the forest floor and scratch through the leaf litter and superficial soil layers, invaded by uropeltids in search of prey. The birds were formerly extremely common, moving in large flocks that aggregated in mast fruiting sites. Fowl are visual hunters and have good color perception.

The kinds of conclusions deriving from comparison of behavior, shape and color patterns of uropeltids with those of other lizards and snakes are intrinsically flawed; they represent possibilities rather than probabilities. The only thing that endows the conclusions with some level of respectability is the ever increasing amount of detailed experimental observation on multiple other species. Even then, it is best to increase the robustness of the conclusion by actual test of interactions between potential prey and possible predator. These considerations led me to carry out some initial tests on the interaction of birds and uropeltids.

EXPERIMENTS WITH BIRDS

Two such tests were possible. The first test (in November 1974) involved a small flock of chickens maintained on a recently cleared area near Bibilegama in the vicinity of Namunukula, Sri Lanka. The appearance of these local chickens was very close to that of the endemic jungle fowl; consequently, it was to be assumed that these individuals might share the behavior of the wild population. The second set of tests was run two years later (on 8 August 1976), utilizing caged spur fowl, jungle fowl and pea fowl in the enclosures of the Colombo Zoological Garden. The jungle fowl were housed by themselves in an approximately 3 metre by 3 metre enclosure. The pea fowl were running in the open area, and the spur fowl, as well as a number of other birds, were in a very large enclosure combining open areas and shrubs planted among open patches. In most cases, the animals were used to intermittent feeding by hand and showed no particular fear of people.

The domestic chickens were offered pieces of cracker, boiled rice, and worms, all spread randomly over the ground. The cereals were swallowed with a single peck-swallow movement, unless more than particle was picked up at a time. Whenever earthworms were introduced, the birds pecked at them and then flipped them through the air two or three times before swallowing them.

After the birds had become used to our presence, we released a living *Rhinophis drummondhayi,* approximately 15 cm long. The snake started moving but did not move concertedly across the surface, rather making ineffective attempts at burrowing into the hard soil. The chickens noticed the snake (when passing less than 75 cm away) but initially seemed to be afraid, moving backward as they noted its tail waving movement. They would peck at grain in its vicinity and cock their head sideways to watch. Suddenly, one of the chickens darted approximately 30 cm, bit the snake, lifting it off the ground and tossing it perhaps 50 cm. The bird followed immediately, pecked again and repeated the flip. There were two important aspects of this behavior. The first was that the peck-flipping was repeated many times without any attempt at swallowing. The second was that the snake initially waved the caudal tip, enhancing a head image, and that more than 90 per cent of the bites were directed at this caudal tip.

After approximately 35 flips, the bird was disturbed and the snake retrieved essentially undamaged. When placed on soft soil, it burrowed effectively at almost normal speed. After being chased away from the prey, the bird proved to be still hungry and immediately started feeding. Earthworms offered immediately thereafter were swallowed after 2 to 5 flips; however, a single centipede was flipped at least a dozen times before it was lost after hitting some bushes. A second trial proceeded similarly.

A series of preliminary experiments utilizing the wild-caught birds in the zoo provided approximately equivalent results. The zoo animals reacted like the domestic chickens to other possible food items. They fed on grain with single pecks, used not more than 5 peck/flips for worms, and a markedly greater series for centipedes.

Several specimens of the patterned *Rhinophis drummondhayi* and the unicolored black *R. philippinus* were then offered to three species of birds in a random pattern. If swallowing had not occurred at the 35th peck, they were removed. Some sample observations follow.

Jungle fowl: A female was immediately attracted to the *R. philippinus* moving toward it from 2 m away. She pecked it, whereupon the snake started curling randomly and was pecked four more times. In each case, the peck hit the tail. The snake was then checked and showed no damage. Upon release, the snake curled about a bush. The bird accidentally bit the snake's head twice and then continued to peck at the tail. The snake did not seem damaged, but kept on moving in the same pattern. Apparently disturbed by the observers, the bird then bit the snake at midbody and carried it to another part of the cage. The bite clearly hurt the snake; although its skin was not broken the internal organs may have been crushed.

The snake was then left on another open spot and the female returned to it at intervals, peck-flipping it whenever it moved. Another female then took over and kept shaking and flipping it for more than four minutes. The frequency of tail strike was over 95 per cent (it may have been higher; however, we only scored for tail strikes when the snake was unequivocally seen to have been hit in the tail). A male bird moved by but ignored the snake. The female finally swallowed the snake 22 minutes after the initial attack.

When another *R. philippinus* was exposed to a pair of jungle fowl they showed only faint interest. In another cage, a *R. philippinus* dug very fast. Although the fowl pecked its tail, the snake escaped. Observations on spurfowl (*Gallopodus bicalcarata*) gave similar results.

Neither species attacked the *R. drummondhayi*; they repeatedly approached the specimens and then backed off, seemingly disturbed by its bright color markings. Several jungle fowl repeatedly walked around specimens, looked at them and walked away, all the time feeding on other items. Only once was a snake bitten; it had crawled right up to the cock, touching its feet. The bite was directed at the head, but the snake seemed unharmed.

Peafowl: The large specimens attacked, killed and ate two *R. philippinus*, the first in about 5 min. They treated the *R. drummondhayi* quite differently. One specimen was attacked before the *R. philippinus* had been presented. The flock shifted their attention to these and only then returned to the snake with markings. Twenty-five minutes later, the snake was still crawling about on the solid floor, being pecked every so often and flipped through the air. After 40 minutes, the snake was swallowed; it is uncertain by which of the birds.

Deductions and Further Tests

The initial observations on uropeltids all suggest that these animals were initially adapted to life within tunnels through the soils of moist tropical forests (Gans 1976, 1978). Subsequent studies have confirmed that the caudal specializations primarily represent defensive devices, reducing the potential effect of snake and perhaps other subterranean predators (Gans and Baic 1977). It now appears that the snakes also show defenses against surface predators. In this category there is the display of cryptic coloration including color matching to that of the prevalent soil, automimicry of head to tail and Batesian mimicry with the model being several species of centipede and the dupe the several species of fowl.

The results of the preliminary tests are in concordance with the basic hypothesis; they do not prove it. What is required at this moment are further studies on a variety of levels. What follows is a testing program which I had intended to carry out in Sri Lanka, but which was prevented by people and circumstances. It may be useful to state this explicitly, as it may encourage studies by others who live closer to the animals involved.

First of all, it would be most useful to obtain additional information on the natural predators of uropeltids. This would involve the analysis of stomach contents of animals killed incidentally or for other studies. As much of Sri Lanka has resident populations of uropeltids, such studies should proceed in lowland, at mid elevation and at high elevation zones. They should also address ontogeny as the juveniles of some species appear to have distinct colors. If possible, they should then search for information about the places at which the predated uropeltids were taken. Did the predators dig them up or encounter only those individuals which for some reason pass the surface accidentally. Next, it would also be of interest to determine the extent to which the predators were those that specifically hunted uropeltids rather than those that fed on them incidental to predation on other organisms.

Next, it would be desirable to see to what extent the several presumed patterns of predator avoidance were effective. Toward this end, one could model uropeltids (using wood, plaster or rubber castings) and paint them in variants of their natural colors before exposing them either in the natural surroundings or with caged predators.

In this phase, it might be interesting to use different substrates, moving or non-moving snake models; on the other hand, this phase could also be modified by using living snakes, but painting them to distinct colors. The preliminary experiments suggest the importance of head/tail reversal. Strikes at the tail induce minor damage. Those at body and head incur a higher risk of major destruction. Here again, two kinds of tests would be possible. The simplest one would require a change of shape, most simply arranged by attaching rubber molds to the anterior and odd posterior portion of the animal, perhaps more simply by making the snakes more truly symmetrical, or by reversing the head and tail shapes. Beyond testing the matter of shape as an isolated variable, it would also be possible to check for shape enhanced by color pattern in the several ways described.

Finally, it would seem useful to test for the mimicry hypothesis. This could be handled in two ways. First, by testing whether the acceptability of centipedes as potential prey changes once they are deprived of their "warning colors", and secondly, by enhancing or masking the lateral, bright colors of uropeltids.

It should be stressed that such a research program should not expect to see absolutes of costs and benefits. Assuming that the basic hypothesis is correct, we could see some benefit to even slight avoidance of predator attention, but this would depend on the predator addressed, being strongest for "to whom it may concern" hunters and weakest to specialists on uropeltids, if there are such. The effectiveness of color matching would also differ, depending on local variants of the soil, surface reflectivity, variants of moisture content, and whereas that of highly hydrophobic snakes surface does not. Also, the intrinsic variability of surface textures and vegetation includes substrates on which even color-matched animals may be very obvious than those on which they would, in any case, be masked by vegetation. Most uropeltids discovered on the surface were apparently there due to flooding or similar circumstances. Thus, unpredictable aspects will affect the responses to be expected.

Furthermore, there is the issue of diversity. The ranges of many uropeltids are quite restricted, generally likely to be far more restricted than those of their predators. Is there a functional basis to the local color variants of the different snakes, or does this reflect phylogenetic or developmental aspects? All of these are aspects for which we cannot provide believable responses until we have additional data regarding these animals and their possible predators. Uncertainty will remain; however, the next level of tests should indicate to what extent we are on the correct track.

ACKNOWLEDGEMENTS

I wish to dedicate this paper to the hundreds of plantation workers, small farmers, rubber tappers, tea pickers, drainage workers, school teachers and their students, and others whom we met during our travels and who not only helped us, but often extended personal hospitality and advice. I am grateful to Prasanna Fernando, who participated in the first field trial and to the staff of the Colombo Zoo who assisted with trials there. During field work in Sri Lanka, I was able to utilize vehicles of the Smithsonian Institution's Entomological Field Project. Some aspects of all of these studies and the preparation of the present report were supported by the National Science Foundation, most recently under DEB 8509490.

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PHOTOGRAPHIC RECORD OF THE JERDON'S OR DOUBLE-BANDED COURSER *CURSORIUS BITORQUATUS*

BHARAT BHUSHAN[1]

(*With a colour plate*)

INTRODUCTION

The Jerdon's or Double-banded Courser *Cursorius bitorquatus* had been resighted after 86 years (since its last record in 1900) in the Lankamalai hill-range areas on 19 January 1986 (Bhushan 1986). The events leading upto the resighting and previous records by Jerdon near Cuddapah (Blyth 1848), Blanford near the Godavari at Bhadrachallam (Blanford 1898), and, by Campbell near Anantapur (Ali 1977) have been described in detail in my earlier paper (Bhushan 1986b). Failure to record the Jerdon's Courser after the 1900 sighting had led to the species being considered as either extinct or nearly so (Ripley 1952, 1961, Greenway 1958, Howard and Moore 1980, Walters 1980, King 1981). The Jerdon's Courser was known only from the two skins collected by Blanford, now housed in the British Museum, prior to my January 1986 record.

Apart from the communications mentioned above, very little biological work has been done on the Jerdon's Courser. The present study formed part of the Bombay Natural History Society's (BNHS) research project "Study of Ecology of Rare and Endangered Species of Wildlife and their Habitat" funded by the Fish and Wildlife Service, USA, through the Ministry of Environment, Forests and Wildlife, Govt. of India.

The study has been conducted at the Lankamalai hill-range area during discontinuous study-periods from January to May and September to October 1986. The main study area was the foothill-scrub expanses below Lankamalai hills near Reddipalli and Konduru villages of Atlur Mandal, Cuddapah district of Andhra Pradesh.

The Lankamalai hills are part of the Lankamalai Reserve Forest in the Siddavatam Range of Cuddapah Forest Division of Andhra Pradesh. The main study area refers to the foothill-scrub intersected by the reserve forest boundary line and also considers the scrub expanses in the non-reserve forest areas. Both areas are referred to as 'above' and 'below' the line (Bhushan 1986b, p. 10).

The Lankamalai foothill-scrub forest types were both Thorny and Non-Thorny scrub jungle patches (Champion & Seth 1968). While the Thorny scrub consisted of *Acacia, Zizyphus* and *Carissa,* the Non-Thorny Scrub was of *Cassia, Hardwickia, Dalbergia, Butea* and *Anogeissus* among other species. Further ahead, above the line, towards the lower slopes are *Hardwickia binata* forests followed by Thorn forests dominated by *Anogeissus* along with *Albizzia, Acacia,* and *Zizyphus* (Reddy 1983, Bhushan 1986b).

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METHODOLOGY

The preliminary surveys in 1985 had involved eliciting information from locals about their knowledge of the Double-banded Courser's existence (Bhushan 1985 a & b). Field-work in 1986 was undertaken with the help of individuals who knew exact locations of the Courser (Bhushan 1986 a & b).

Field work involved walking about in the area, listing the birds seen and keeping track of the extent of habitat-types. This was alternated by using a spotterscope of 10 × magnification. Equipment used also included a 12 × 50 pair of binoculars. Photographs were taken with an Asahi Pentax Program Plus Camera with a normal 50 mm & 70-210 mm zoom lenses. A wide-angled instamatic camera was also utilised.

RESULTS

A solitary Jerdon's Courser was sighted on 24th September 1986, in similar habitat as the January sighting and was approximately two kilometres north of the same. The courser has also been reliably sighted by local Reddipalli villagers, Aitanna and Pulliah, at another location in the foothill scrub in between the other two sightings on 10th May 1986.

The wto coursers seen in January at night had flown up and glided down noiselessly into open patches. The September sighting was at 0630-0715 hours. The bird was sighted in a *Carissa* bush (height *c.* 30 cm) and walked off on being flushed accidentally by my near presence. It sat next to a stone beside a dead branch in the open patch and remained motionless as I kept approaching while photographing it. The courser then stood up and walked off behind an *Acacia* bush (2.5 m tall) as I went closer, stood for less than 30 seconds, and sat under its canopy in the shadow of the stem. The bird later walked to another bush, went under the canopy, stood in the shade for about a minute, flew up and beyond the bush-line against the hills. It could not be sighted later.

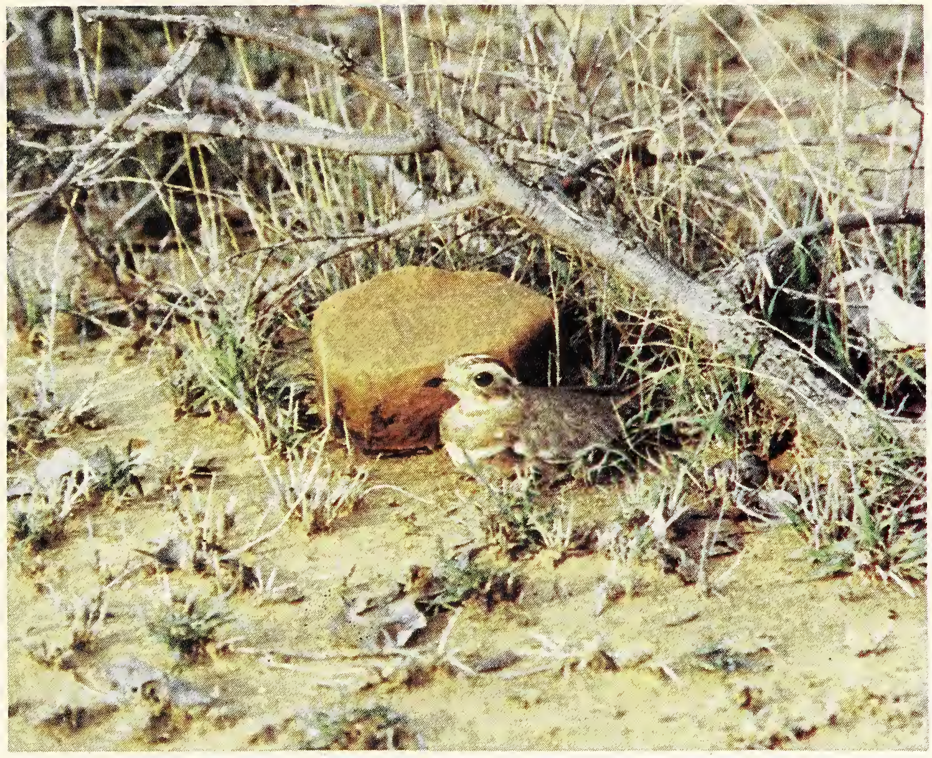
The three sightings have been in similar habitat-patches in the foothill scrub. The Jerdon's Courser seems to be almost restricted to bare grassless patches of open ground amidst scrub bushes. These patches have a cover of grass only during the monsoon and is under grazing pressure otherwise. The three open patches in which the courser was seen are not more than 500 sq. m in area. There are similar sized open patches all along the Lankamalai foothills both above and below the line. The photographs now constitute the only known positive evidence of the species' presence in its habitat.

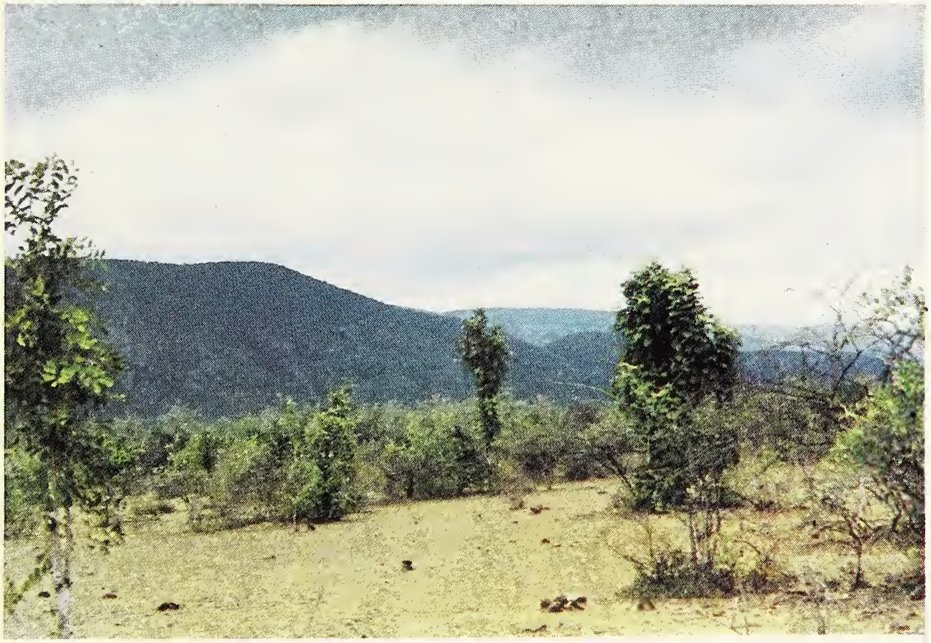
Below the line and after the scrub areas near Reddipalli and Konduru villages, are present open bare grazing grounds larger than 500 sq. m and nearly 1-3 sq. km in area. The vegetation in these larger open patches comprise of shrub bushes towards the reserve forest area and of cultivation towards the village areas. The Jerdon's Courser has never been sighted in the larger open patches even by locals who frequent these grounds regularly.

DISCUSSION

Intruder reaction

The Jerdon's or Double-banded Courser's reaction to my presence during the January and September sighting is similar to the *Rhinoptilus* behaviour recorded for presence of an intruder. Bannermann (1931) records Major Hutson describing a *R. chalcopterus* sighted on a "newly burnt patch in fairly open





Above: The Jerdon's Courser. *Below*: Habitat of the Jerdon's Courser.
(*Photos*: Author)

bush. It stood motionless when approached and only took to flight when he was within six yards, and then landed again and stood motionless once more. This performance during which it did not utter a note, was repeated several times".

Andersson, in the same account, describes his experience in attempting to flush the *chalcopterus* from the undergrowth. He mentions, "when suddenly flushed, the bird darts behind a tree" where it stops, and continues its "flight by hard running, only using its wings in its utmost need".

Rudolf Braun, a German naturalist, recorded the *chalcopterus* getting up "right under one's feet, coming down again 30-40 metres away and usually remains perfectly motionless". (Bannermann 1951).

Habitat

Jerdon (1877) had found the Double-handed Courser to inhabit "rocky and undulating ground with thin forest jungle" and believed the species to be a "mountain form of *Cursorius*, frequenting rocky hills with thin jungle". Blanford (1898) recorded the species in "thin forest or high scrub, never in open ground" and "never saw any on hills" in contrast to Jerdon's belief. I have described the Double-banded Courser being present in similar habitat in my earlier communication (Bhushan 1986 b).

Among the African species, the Bronze-winged Courser *R. chalcopterus* prefers bush-covered country and also utilizes "little bare, gravelly patches among the woods" as breeding spots (Bannermann 1931). The Two-banded Courser *R. africanus* is a "bird of rocky thorn scrub country, sandy plains and flat deserts" while the Heuglin's or Three-banded Courser *R. cinctus* is rarely found away from thick thorn scrub (Mackworth-Praed and Grant 1952).

Later communications record the three-banded Courser nesting on bare ground, next to a pile of windblown leaves about one metre from the base of a small *Acacia* tree (Kemp and Maclean 1973). Uys and Underhill (1977) recorded the Two-banded Courser breeding on bare ground, a few metres away from stunted bushes on both the occasions the bird had allowed the observers to approach very closely in a manner similar to my September sighting of the *bitorquatus* during which, however, I could not record any breeding. The habitat is similar to descriptions of the same for the three African *Rhinoptilus.*

Maclean (1967) describes the habitat of the Double-banded Courser *R. africanus* as 'calcrete covered with small woody shrubblets between six inches and a foot", and, records that the *africanus* is "almost confined to the calcrete, which is usually bare between the shrublets, except after good rains..."; He also mentions that "the barest areas where drinking antelopes have trampled the vegetation are usually avoided by the coursers".

ACKNOWLEDGEMENTS

The Bombay Natural History Society permitted me to undertake the survey under their research project on Endangered Species. This study received financial assistance from the Fish and Wildlife Service, U.S.A. in the form of a grant (USDIFWS Grant No. 8851-658-02) received through the Department of Wildlife, Ministry of Environment, Forests and Wildlife, Government of India. I am grateful to these organisations for their support.

Grateful thanks is due to Mr. J. C. Daniel, Curator, BNHS, for his encouragement and supervision throughout the many stages in the final outcome of the survey.

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The Andhra Pradesh Forest Department and particularly Mr Pushp Kumar, ACCF-Wildlife for the facilities granted.

To my parents and sister who never showed their anxiety at my absence during the survey — mere thanks would be insufficient.

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THE EARLIEST RECORD OF A WHITE TIGER (*PANTHERA TIGRIS*)

DIVYABHANUSINH[1]

(*With a colour plate*)

Mutant "white" tigers are a fairly well documented phenomenon in India. This *journal* has recorded no less than 17 instances of "white" tigers being shot in India between 1907 and 1933 (Gee 1954), i.e. in a period of 16 years only. Several other instances are recorded of sightings and trophies of such animals as well. The most famous and recent case being that of Mohan the great while partriarch of Rewa, whose descendants stock the zoos the world over. There has been only one recorded instance of true albino tigers, this is of two cubs shot in Cooch Bihar in 1922. (Narayan 1922).

The earliest known record of a "white" tiger however is that of the Mughal period and more precisely of the year 1561 A.D. Emperor Akbar who ruled from 1556 A.D. to 1605 A.D., caused his life and times to be recorded by his trusted courtier Abul Fazl. His "*Akbar Nama*" became a detailed account of the Emperor's reign. It had run into 2 volumes and the third one was incomplete when he was waylaid and killed by the forces of Raja Bir Singh Deo of Orcha on Jahangir's orders in 1602 A.D. barely 3 years before Akbar's own death. There are two illustrated versions of the chronicle that survive in parts. One is the second volume of *Akbar Nama* which is the royal copy bearing Jahangir's own signature preserved in Victoria and Albert Museum, London. The first volume is untraceable while the third is dispersed. The second volume covers the period of 1560 to 1577/8 A.D. It has in all one hundred and sixteen miniature paintings executed by forty nine painters and sometimes as many as three of them worked on the same painting. The other illustrated versions was painted between 1603 and 1605 A.D. and it is preserved in the British Museum Library, London and Chester Beatty Library, Dublin.

Every painting in *Akbar Nama* illustrates an episode in the life of the Emperor. The painting which interests us here, illustrates one such episode in the royal copy in Victoria and Albert Museum but the same episode is not illustrated in the other surviving version referred here. The episode in question, occurred near Gwalior in 1561 A.D. in the 5th regnal year when Akbar was returning to Agra from Malwa. It is recorded thus:

"His Majesty went on stage by stage, hunting and shooting but also going on rapidly. When his crescent standard cast their rays on the territory appertaining to the fort of Narwar, a tiger, such as may terrify the leopard of heaven, came out of the forest with five cubs and on the track by which the cavalcade was proceeding. His Majesty the Shahinshah who had the strength of the lion of God in his arms and the coat of mail of the Divine protection on his breast, went alone and without hesitation in front of the iron-clawed fiery-natured wild animal. When the spectators beheld this the hair on their bodies stood erect and sweat distilled from their pores. His Majesty with swift foot and alert arm attacked the brute and killed it by one stroke...

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"The wild beast, so great and terrible, fell bleeding to the dust before the strength of his arm and the might of his courage, and a shout arose one all sides. This was the first beast of prey which His Majesty personally attacked. Its cubs were killed by the swords and arrows of a number of brave men who were in attendance on the sublime stirup" (pp. 222-3, Vol. II, Beveridge, 1910).

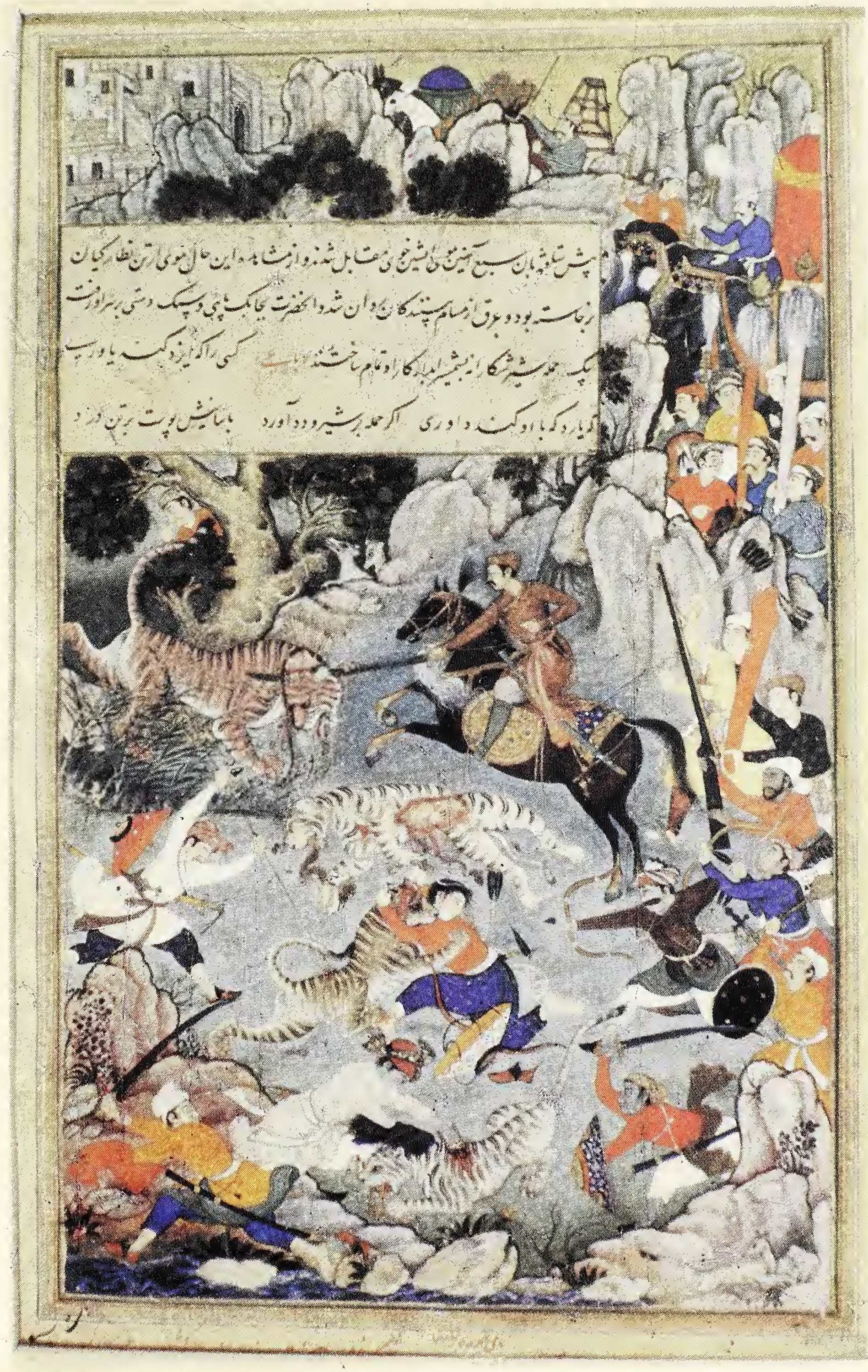
This episode is illustrated with a double page painting. The right page shows young Akbar astride a black mount slaying the tigress with his sword, some of his courtiers are looking on. A "white" tiger lies disembowelled and dead below Akbars' horse. Another normal coloured tiger has attacked a soldier and is in the process of being speared, while a third tiger again a "white" one, is being stabbed with a "khanjar" by one soldier and another is about to attack it with a sword.

The left page shows a tiger dead and lying on its back with its four feet in the air while another is about to meet its end, both these are of normal colour. From the paintings we see that all the five cubs are large, almost fully grown.

The narrative does not mention "white" tiger cubs, yet the painting is clear and leaves us in no doubt. Mr. Robert Skelton of Victoria and Albert Museum, London, and an authority on Mughal paintings, informs me that the two tigers in the painting in question are of a "light fawn" colour (Skelton, *pers. com.* 1984) which is not the normal colour of tigers at all. Then why is the next silent?

Abul Fazl started working on the chronicle around 1588 A.D. (p. 34, Sen 1984) while this incident took place in 1561 A.D. As such his account is hearsay committed to writing 27 years after the event. There is yet another factor: Abul Fazl's chronicle is one long essay in the celebration of the Emperor and his greatness as is evident from the reading of the text of *Akbar Nama.* In the narrative of this episode the object is very clearly to illustrate Akbar's bold and fearless action and to record the fact that this was the first time that the Emperor had personally attacked and killed a beast of prey. The colour of the tigers slain, and in this case of those killed by others such as soldiers or courtiers, was of little consequence. The Persian text uses the word "babri" which is used interchangeably for both tigers and lions and there is no description of the striped cats which again goes to show the thrust of the chronicle towards the Emperor's bravery rather than the uniqueness of the animal's colour.

The painting on the right page was composed by Basawan and painted by Tara the elder. The faces were painted by Basawan. Whereas the left page was composed by Basawan and painted by Sarwan (p. 69, Sen, 1984). Of 116 paintings that survive in the second volume of *Akbar Nama,* ten were composed or painted by Basawan and two by Tara the elder. Each and every painting pertaining to wildlife in the Chronicle is very accurately executed. A keen observer of wildlife would be amazed at the accurate reproduction of animals in *Akbar Nama* paintings and he would inevitably reach a conclusion that the painters had a personal knowledge of their subjects. The colour of the two tiger cubs in question is so unmistakably different, "light fawn", that it cannot be ascribed to chance. To me the painting appears to have been executed on the basis of authentic eye witness reports. It is on record that painters often



"Akbar slays a tigress which attacked the royal cavalcade." This painting is the right hand side of a double page illustration in the Akbarnama. The colour of the two almost full grown cubs is light fawn in sharp contrast to that of the mother being slain by the Emperor Akbar.

accompanied the Emperor during expeditions and journeys. Basawan may well have witnessed the scene at Narwar, Abul Fazl joined Akbar's service much later.

A dyslexic emperor (for Akbar could neither read nor write and he is believed to have suffered from dyslexia) may overlook an inaccuracy of the written word, but surely an emperor of Akbar's keenness for the hunt and the chase would not overlook a mistake if it was one, in rendering the correct colour of tigers which were common if not favourite objects of imperial hunting persuits. What is more, while this royal copy of *Akbar Nama* bears Emperor Jahangir's signature, even he, ever the keen observer of Nature, is silent about the tiger cubs in the painting. If something was amiss, he would surely have noted it.

In fact, what we are witnessing here are two mutant "white" tigers. The painting has been published several times starting with Wilhelm Staude in 1932, Stuart Cary Welch in 1960 and 1964 (p. 69, Sen, 1984), Bamber Gascoigne (a poor colour reproduction in this case) in 1971 (p. 112-3, Gascoigne, 1971), Geeti Sen in 1984 (pp. 48, 69, Sen, 1984), John Reay in 1985 (pp. 216-7, Reay, 1985), Stuart Cary Welch in 1985 (pp. 147-8, Welch, 1985), and others. Though the painting has been scrutinised by many historians and critics, it is strange that the "white" tigers have escaped attention till now. The only explanation is that India's rich heritage has been rarely examined to record or study its natural history.

ACKNOWLEDGEMENTS

I am greatful to Dr. Asok Kumar Das, Director, Maharaja Sawai Man Singh II Museum, Jaipur for bringing to my attention this particular painting in the Akbarnama.

I am also grateful to Mr. Robert Skelton of the Victoria and Albert Museum, London for offering his views on the painting in question.

Their help has greatly enriched this article. However, I am solely responsible for shortcomings, if any.

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STATUS OF WILDLIFE AND HABITAT CONSERVATION IN KARNATAKA

K. ULLAS KARANTH[1]

(*With a map*)

This paper reviews the status of wildlife and habitats of Karnataka State in India. The overview briefly covers (i) Available habitat types in the major biogeographic zones of the state; (ii) Current distribution of important mammalian species; (iii) Protection status of wildlife and habitats in the recent years; and (iv) The existing and proposed nature reserve areas in Karnataka.

INTRODUCTION

Karnataka State in South-Western India is a region naturally endowed with a diversity of bioclimatic, topographic and edaphic variations (Pascal 1982, Rama Prasad and Malhotra 1984). For example, the annual precipitation of the order of 6000 mm at the Western edge of the State declines to less than 800 mm within a short distance of about 150 kms Eastwards. The coastal plains which are virtually at sea level rise precipitously to the Western ghat ridges at around 1500 m elevation only to slope down gently on to the Deccan plateau Eastwards. The soil types range from coastal laterites through the sandy loams of the Southern plateau to the deep black cotton soils of the Northern plains.

As a result of such natural variations, the State has a variety of wildlife habitats and a rich diversity of plant and animal communities. These habitats include many types of forests: Montane Shola, Wet-evergreen, Semi-evergreen, Moist deciduous, Dry deciduous, Dry evergreen, Thorn scrub as well as Riverine, Mangrove and other wetland vegetations. In recent times, the State has made some determined attempts to conserve this biological wealth. Arguably, this effort has been more effective than in many other parts of India, particularly in terms of restricting forest exploitation and setting up nature reserves.

In this paper I have attempted to present an overview of the conservation status of Karnataka State's wildlife and wildlife habitats. This overview is primarily restricted to terrestrial habitats and focusses on the larger mammalian fauna. I have briefly mentioned each of the habitats occurring in the four biogeographic sub-regions of the State: (1) West coast plains; (2) Western ghat slopes and foothills; (3) Southern plateau and Eastern ghat hills; (4) Northern plateau (Map 1). A brief review of the conservation status of these habitats is here. The current presence/absence data on the distribution of important mammalian species is also included as an indicator of the status of wildlife. I have summarised additional information about some species which are of special conservation interest. This is followed by a brief section on problems of wildlife and habitat protection in the State and existing and suggested nature reserve areas.

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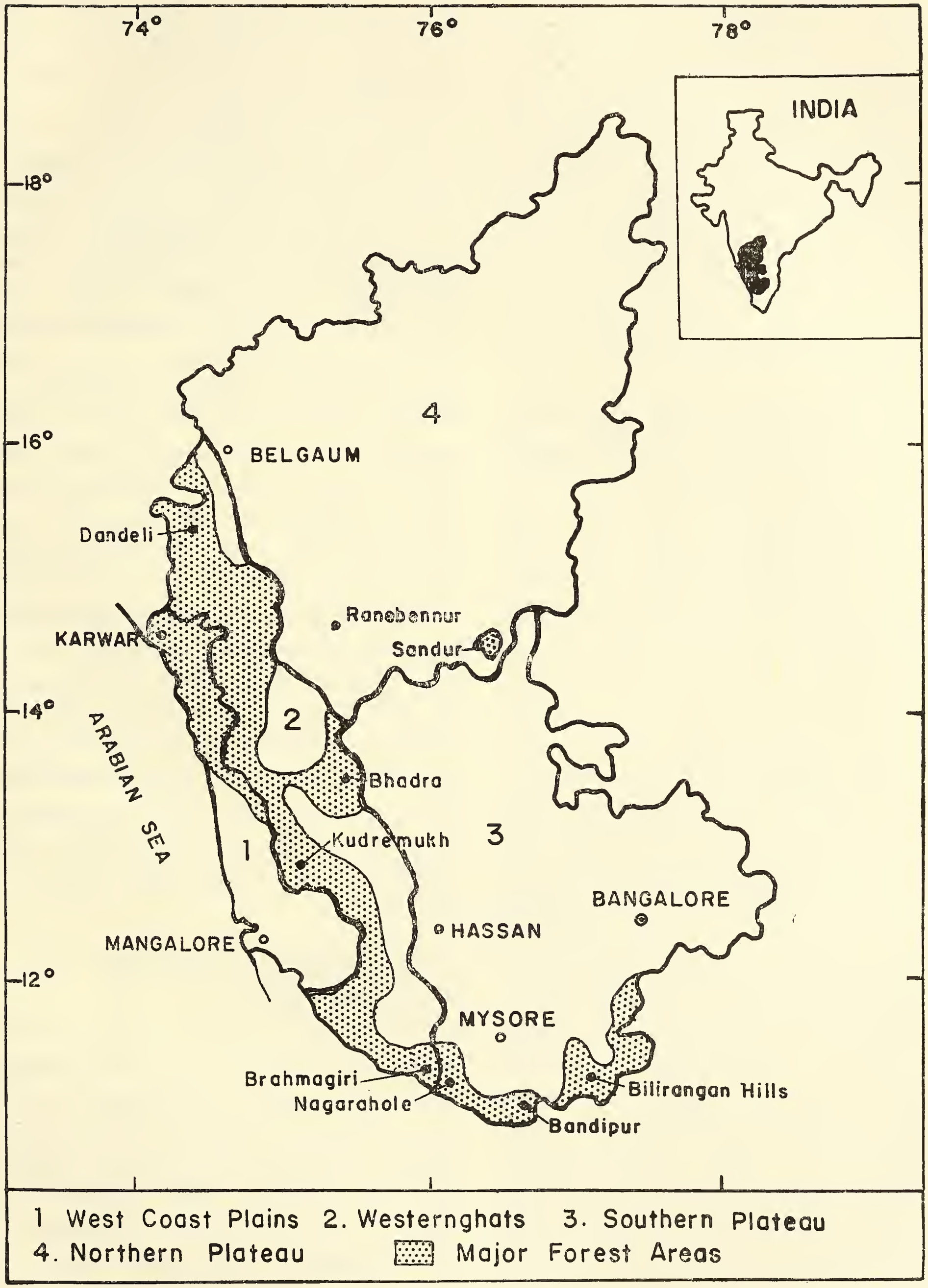
74°
76°
78°
18°
16°
14°
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INDIA
4
BELGAUM
Dandeli
KARWAR
Ranebennur
Sandur
ARABIAN SEA
2
Bhadra
1
Kudremukh
3
HASSAN
BANGALORE
MANGALORE
MYSORE
Brahmagiri
Nagarahole
Bilirangan Hills
Bandipur
1 West Coast Plains
2. Westernghats
3. Southern Plateau
4. Northern Plateau
Major Forest Areas

Map. 1. Karnataka — Bio-geographic regions and important wildlife habitats.

Apart from my own field notes, I have consulted several published and unpublished accounts by various authors. These are quoted in the appropriate context. On the whole this paper essentially highlights gaps in our knowledge about the faunal distribution in Karnataka and is meant to serve as a basis for more detailed work in future.

Wildlife Habitats in Karnataka

Coastal Plains, Western Ghat Slopes and Foothills

These two regions receive very high rainfall ranging around 1500-5000 + mm annually (Pascal 1982). The coastal plains have two main littoral habitat types — the sand dune vegetation on the seashore and the mangroves on the coast and riverine estuaries. A recent comprehensive survey by Untwale and Wafar (1986) highlights the precarious status of these habitats and estimates that only a few hundred hectares of these remain intact. It also documents their ongoing destruction by the local people for fuel, timber, conversion to agricultural uses as well as other developmental activities. These habitats are almost entirely outside the control of forest/wildlife departments and no effective protection has been possible as a result.

Most of the climax evergreen forests of the coastal plains were also not protected as reserved forests in the late 19th century, being left in the custody of local villages as common lands. These have totally vanished due to the reckless abuse by these custodians (Stebbing 1929). Such areas are now covered by degraded physiognomies like scattered shrubs, grass and tree savannas and thickets (Pascal *et al.* 1982). Even in the small pockets of reserved forests on coastal plains, the climax evergreen forest type is almost absent, having degraded into semi-evergreen and moist deciduous formations due to biotic interferences like lopping for fuel wood/green manure, cattle grazing and forestry operations.

The low and medium elevation climax evergreen forests are now confined mainly to the slopes of the Western ghats and their outspurs to the South of 14°N latitude and are fairly extensive. It is officially estimated that about 4300 km^2 area is under evergreen type and about 1500 km^2 area is under semi-evergreen type in Karnataka. These evergreens belong to several distinct vegetation series with characteristic plant associations as described by Pascal *et al.* (1982). Most of these are subtypes of the *Dipterocarpus-Mesua-Palaquium* series. However, to the North of Sharavathi river (14°N lat.) the *Persea-Macarantha-Diospyros-Holigarna* type and *Memecylon-Syzigium-Actinodaphne* types also occur. The semi evergreen series *Diospyros-Dysoxylum malabaricum-Persea macarantha,* locally known as "Kan type" is unique to this region. The high elevation montane shola vegetation is found only in small patches of *Schefflera-Gordonia-Meliosma* type forests occurring amidst extensive grass savannas above 1250 m elevation, primarily in Chikmagalur and Kodagu districts.

Southern Plateau, Eastern Ghat Hills and Northern Plains

The elevated plateau country that extends Eastwards from the foot of the Western ghats, receives an annual precipitation ranging between 1500 mm on the West to about 600 mm on the East. The plateau region South of 14°N lat. approximately still supports extensive climax deciduous forests. In tracts which receive precipitation in excess of about 1200 mm these forests are moist deciduous and belong to the *Lagerstroemia-Tectona-Dillenia* series occurring mainly in Belgaum, Uttara Kannada, Shimoga, Chickmagalur, Hassan, Kodagu and Mysore districts. These moist deciduous forests are estimated to cover about 5700 km^2 area in the State, a figure which includes secondary moist deciduous forests of the coastal plains also. Most of these forests are woodlands rather than dense forests due to selective logging. A substantial area of moist forests have been converted to plantations of teak, eucalyptus, rubber, cocoa and other crops in the past.

The natural climax vegetations over most of the plateau region receiving less than about 1100 mm annual precipitation are dry deciduous forests. These are primarily of two types: *Anogeissus-Tectona-Terminalia* series in the Southern plateau region and *Anogeissus-Hardwickia* series in the North. A transitional type, *Anogeissus-Chloroxylon-Albizzia* series is also recorded (Saldanha 1984). The Southern plateau and the Eastern ghat hills still have substantial areas under the first type in the reserved forests. The second type is confined to degraded small pockets of reserved forests, which occupy only around 5% of the land area in the Northern plateau and probably no patches in near climax conditions are available anywhere in the State.

The other vegetation types that are of interest which occur in small fragments are: (i) Dry evergreen forests in Eastern part of both North and Southern plateau; (ii) Semi arid thorn forests in drier parts of Bellary and Chitradurga; (iii) Riverine gallery forests along the Kaveri river in Southern plateau region; and (iv) 'Evergreen' shola type patches dominated by *Shorea talura* in the upper reaches of Mahadeshwara malai hills in the Eastern ghats.

STATUS OF WILDLIFE

The diverse habitat types described above naturally support an equally rich diversity of animal species; mammals, birds, reptiles, amphibians, fishes and insects etc. No detailed inventory of the faunal wealth is available. Further, the recent conservation status of most of the non-mammalian species is virtually unassessed. I have restricted this overview of conservation status of wildlife in the State primarily to some of the terrestrial mammals.

Table 1 contains the available presence/absence data on the current distribution of 53 mammalian species in each of the four regions of the State described earlier. Some typical localities where each species occurs is also mentioned where possible. The following notes provide additional information on some species (Scientific names in Table 1) which are of special interest.

Primates

The earlier accounts (Green and Minkowski 1977, Kurup 1978) have considered the lion-tailed macaque as a species on the verge of extinction in Karnataka and that conservation efforts for this species are not viable in the State for want of adequate habitats. The population estimates were placed as low as two groups in the entire State without any detailed survey. Subsequent efforts by Bhat (1984) indicated additional localities. In 1983-84 a detailed field survey by me (Karanth 1985) has revealed that about 1000 km^2 area of potential liontailed macaque habitat is available in Karnataka. Based on sighting reports by reliable informants (the same technique used by Green and Minkowski 1977, Kurup 1978), actual sightings and wild caught captives, locations of 133 groups of macaques between 14°30′-12°N lat. in Karnataka

TABLE 1

DISTRIBUTION OF WILD MAMMALS IN KARNATAKA

Sl. No.	Common Name	Scientific Name	Present occurrence in different regions				Typical Localities
			West Coast	Western ghats	Plateau (South)	Plateau (North)	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1.	Bonnet Macaque	*Macaca radiata*	P	P	P	P	All over the State
2.	Liontailed Macaque	*M. silenus*	A*	P	A	A	Brahmagiris, Kudremukh
3.	Hanuman Langur	*Presbytis entellus*	P	P	P	P	All over the State
4.	Nilgiri Langur	*P. johnii*	A	P	A	A	Brahmagiris
5.	Slender Loris	*Loris tardigradus*	L	P	P	L	Nagarahole, Bandipur
6.	Tiger	*Panthera tigris*	A*	P	P	A*	Nagarahole, Bhadra
7.	Leopard	*P. pardus*	P	P	P	P	Nagarahole, Bandipur
8.	Fishing Cat	*Felis viverrina*	O*	A	A	A	—
9.	Jungle Cat	*F. chaus*	P	P	P	P	Mangalore, Bandipur
10.	Leopard Cat	*F. bengalensis*	A	L	P	O	Nagarahole, Bangalore
11.	Rusty Spotted Cat	*F. rubiginosa*	A	L	P	O	Nagarahole, Bangalore District
12.	Desert Cat	*F. lybica*	A	A	A	O	—
13.	Cheetah	*Acionyx jubatus*	A	A	A*	A*	—
14.	Malabar Civet	*Viverra megaspila*	L	P	O	A	Kudremukh
15.	Small Indian Civet	*Viverricula indica*	P	P	P	L	Common everywhere
16.	Common Palm Civet	*Paradoxurus hermaphroditus*	P	P	P	L	Common everywhere
17.	Brown Palm Civet	*P. jerdoni*	A	O*	A	A	—
18.	Common Mongoose	*Herpestes edwardsi*	P	P	P	P	Bandipur, Ranebennur
19.	Stripenecked Mongoose	*H. vitticollis*	A	P	P	A	Bandipur, Nagarahole
20.	Brown Mongoose	*H. fuscus*	A	P	P	A	Nagarahole
21.	Ruddy Mongoose	*H. smithi*	A	L	P	A	Bandipur
22.	Striped Hyena	*Hyaena hyaena*	P	A	P	P	Mangalore, Mysore District
23.	Wolf	*Canis lupus*	A	A	P	P	Melkote, Ranebennur
24.	Golden Jackal	*C. aureus*	P	P	P	P	Common everywhere
25.	Indian fox	*Vulpes bengalensis*	A	A	P	P	Ranebennur
26.	Dhole	*Cuon alpinus*	A	P	P	A	Bandipur, Dandeli
27.	Sloth Bear	*Melursus ursinus*	A	P	P	P	Nagarahole, Bangalore District

TABLE 1 (contd.)

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
28.	Common Otter	*Lutra lutra*	P	P	P	A	Kabini, Bhadra reservoirs
29.	Smooth Indian Otter	*L. perspicillata*	A	A	O	L	—
30.	Clawless Otter	*Aonyx cinerea*	A	P	A	A	Brahmagiris
31.	Nilgiri Marten	*Martes gwatkinsi*	A	P	A	A	Brahmagiris
32.	Honey Badger	*Mellivora capensis*	A	A	P	L	Kolar District
33.	Indian Elephant	*Elephas maximus*	A*	P	P	A	Nagarahole, Biligirirangans
34.	Gaur	*Bos gaurus*	A*	P	P	A	Dandeli, Kudremukh
35.	Nilgiri Tahr	*Hemitragus hylocrius*	A	A*	A	A	—
36.	Chinkara	*Gazella gazella*	A	A	A*	P	Sandur
37.	Blackbuck	*Antilope cervicapra*	A	A	P	P	Naganapura, Ranebennur
38.	Four horned Antelope	*Tetracerus quadricornis*	A	A	P	P	Bandipur, Sandur
39.	Nilgai	*Boselephus tragocamelus*	A	A	A*	A*	—
40.	Sambar	*Cervus unicolor*	L	P	P	L	Kudremukh, Nagarahole
41.	Chital	*Axis axis*	P	P	P	P	Bandipur, Dandeli
42.	Muntjac	*Muntiacus muntjak*	P	P	P	O	Bandipur, Brahmagiris
43.	Chevrotain	*Tragulus meminna*	P	P	P	O	Nagarahole
44.	Wild Pig	*Sus scrofa*	P	P	P	P	Common everywhere
45.	Blacknaped Hare	*Lepus nigricollis*	P	P	P	P	Common everywhere
46.	Indian Porcupine	*Hystrix indica*	P	P	P	L	Bandipur, Nagarahole
47.	Giant Squirrel	*Ratufa indica*	L	P	P	A	Nagarahole, Bhadra
48.	Grizzled Giant Squirrel	*Ratufa macroura*	A	A	P	A	Kaveri Valley, Mysore District.
49.	Flying Squirrel	*Petaurista petaurista*	A*	P	P	A	Nagarahole, Bandipur
50.	Pale Hedgehog	*Paraechinus micropus*	O	O	O	O	—
51.	Indian Tree Shrew	*Anathana ellioti*	O	O	O	O	—
52.	Flying Fox	*Pteropus giganteus*	P	P	P	P	Common everywhere
53.	Pangolin	*Manis crassicaudata*	L	L	P	P	Mysore & Bangalore Districts.

Note: P — Present. Based on personal sightings or dead/live specimens or sightings by reliable informants.
L — Likely to be present based on past distribution.
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3.	Hanuman Langur	*Presbytis entellus*	P	P	P	P	All over the State
4.	Nilgiri Langur	*P. johnii*	A	P	A	A	Brahmagiris
5.	Slender Loris	*Loris tardigradus*	L	P	P	L	Nagarahole, Bandipur
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12.	Desert Cat	*F. lybica*	A	A	A	O	—
13.	Cheetah	*Acionyx jubatus*	A	A	A*	A*	—
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15.	Small Indian Civet	*Viverricula indica*	P	P	P	L	Common everywhere
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18.	Common Mongoose	*Herpestes edwardsi*	P	P	P	P	Bandipur, Ranebennur
19.	Stripenecked Mongoose	*H. vitticollis*	A	P	P	A	Bandipur, Nagarahole
20.	Brown Mongoose	*H. fuscus*	A	P	P	A	Nagarahole
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24.	Golden Jackal	*C. aureus*	P	P	P	P	Common everywhere
25.	Indian fox	*Vulpes bengalensis*	A	A	P	P	Ranebennur
26.	Dhole	*Cuon alpinus*	A	P	P	A	Bandipur, Dandeli
27.	Sloth Bear	*Melursus ursinus*	A	P	P	P	Nagarahole, Bangalore District

TABLE 1 (contd.)

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32.	Honey Badger	*Mellivora capensis*	A	A	P	L	Kolar District
33.	Indian Elephant	*Elephas maximus*	A*	P	P	A	Nagarahole, Biligirirangans
34.	Gaur	*Bos gaurus*	A*	P	P	A	Dandeli, Kudremukh
35.	Nilgiri Tahr	*Hemitragus hylocrius*	A	A*	A	A	—
36.	Chinkara	*Gazella gazella*	A	A	A*	P	Sandur
37.	Blackbuck	*Antilope cervicapra*	A	A	P	P	Naganapura, Ranebennur
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39.	Nilgai	*Boselaphus tragocamelus*	A	A	A*	A*	—
40.	Sambar	*Cervus unicolor*	L	P	P	L	Kudremukh, Nagarahole
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46.	Indian Porcupine	*Hystrix indica*	P	P	P	L	Bandipur, Nagarahole
47.	Giant Squirrel	*Ratufa indica*	L	P	P	A	Nagarahole, Bhadra
48.	Grizzled Giant Squirrel	*Ratufa macroura*	A	A	P	A	Kaveri Valley, Mysore District.
49.	Flying Squirrel	*Petaurista petaurista*	A*	P	P	A	Nagarahole, Bandipur
50.	Pale Hedgehog	*Paraechinus micropus*	O	O	O	O	—
51.	Indian Tree Shrew	*Anathana ellioti*	O	O	O	O	—
52.	Flying Fox	*Pteropus giganteus*	P	P	P	P	Common everywhere
53.	Pangolin	*Manis crassicaudata*	L	L	P	P	Mysore & Bangalore Districts.

Note: P — Present. Based on personal sightings or dead/live specimens or sightings by reliable informants.
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Western ghats were determined. The factors that have contributed to the relatively better status of the species in Karnataka when compared to Kerala and Tamil Nadu are: (i) Protection against hunting enjoyed by the species due to cultural factors North of 13°N lat; (ii) Relatively conservation oriented logging practiced in Karnataka State forests; and (iii) The large extent of habitat still remaining in good condition.

The status of Nilgiri langur seems to be precarious and it is now restricted to the Southern extremity of Western ghats in Kodagu district known as Brahmagiris. Situated at the junction of two different evergreen forest types, *Cullenia exarillata* dominant and *Dipterocarpus* dominant, Brahmagiris are unique in that four monkey species; bonnet macaque, liontailed macaque, nilgiri langur, and hanuman langur share the same habitat.

Carnivores

Asiatic cheetah occurred in Karnataka in the past and was called 'Sivangi' in Kannada language (Russel 1900). However, even as early as the 19th century it was apparently rare. Sanderson (1882) saw only six skins with 'native shikaris' during his long experience. Russel (1900) saw five cheetahs together in the Beerambadi forests of Mysore district and shot one of them ! Interestingly, Beerambadi is a dry deciduous forest area and not the typical open plains country associated with Cheetahs further North. However, cheetahs are reported to occur in fairly dense *Acacia* forests in Kenya (M. J. Coe, personal communication). Cheetah has been extinct in the State for over 4-5 decades now.

Breeding populations of tigers occur in Nagarahole, Bandipur and Bhadra sanctuaries where cubs are frequently seen. Tigers also occur in low densities on the Western ghat slopes, other forests of Southern plateau and Eastern ghat hills. Their conservation status has improved considerably since the early seventies and they are reported from localities in which they were eliminated in the 1960s due to poisoning and poaching. However, the official 1984 Tiger Census figure of 202 animals for the State is perhaps an overestimate, primarily due to the overcounts in Bandipur Tiger Reserve due to faulty census methods (Karanth, in press).

Similarly, the status of the leopard has shown a considerable improvement. Partly as a consequence, many dispersing leopards are straying into densely populated areas and getting killed. Long term conservation strategies for these two endangered large felids need to be developed based on scientific studies.

Among the lesser cats, the fishing cat is probably locally extinct in coastal Karnataka because its littoral habitats themselves are almost entirely gone. Rusty spotted cat occurs in Nagarahole National Park and probably in many other areas since I have seen the skin of one shot on the outskirts of Bangalore city.

The rare Malabar Civet was seen by me in 1975 in the Kudremukh area (Karanth 1986) but there is no other information about its present distribution. Similarly, nothing is known about the current distribution of the brown palm civet though some skins in the British Museum collection are from Kodagu district. During my liontailed macaque survey informants in Kodagu mentioned two 'kinds' of tree civets but whether one of them is the brown palm civet or is merely a variant of the common palm civet needs to be verified.

Striped hyena has a curious discontinuous distribution in Karnataka. It occurs in the secondary deciduous forests of the wet coastal plains and once again on the drier parts of Deccan plateau. But it is absent in the intervening large tracts of evergreen and moist deciduous forest areas.

The wolf occurs in small packs in widely scattered localities of Northern and Southern plateau region. 13 wolves were shot in Pavagada taluk in 1983 in a panicky response to a child-lifting scare. Wolves are reported from Gulbarga, Raichur, Bellary, Dharwar, Chitradurga, Tumkur, Kolar, Mandya and Mysore districts. Ranebennur Black Buck Sanctuary in Dharwar district is a good locality where I saw wolves on three occasions in 10 days and also saw tracks of pups. The wolves in Karnataka are preying primarily on sheep rather than on wild antelopes. The wolf habitat in State is now a mosaic of scattered scrub or plantations amidst extensive stretches of farm land. The long term survival of wolves is doubtful because no substantial protected area harbouring them exists in the State now. The other large canid predator, dhole, being a forest-dweller is much better off in nature reserves like Nagarahole, Bandipur, Bhadra and Biligirirangans where it subsists on wild prey. But in some other parts of Karnataka Western ghats like Agumbe and Koppa, dhole are also cattle killers in the absence of sufficient wild prey.

The sloth bear inhabits an amazing diversity of habitats in Karnataka; wet evergreen montane forests of Western ghats, the moist and dry deciduous forests of the plateau and Eastern ghats and boulder strewn hillocks that dot many parts of the tree-less dry plains. Apart from being a specialised termite eater, it apparently has adapted to a wide range of other plant foods in these different habitats.

The clawless otter is adopted to feeding on crustaceans and other small animals of hill streams in the Western ghats of Kodagu district. Apart from the fact that it is occasionally captured by professional hunting tribes with the help of dogs, nothing is known about its present status. The nilgiri marten still occurs in the Western ghats of Kodagu though it has almost vanished from the foothills region. Though an informant mentioned seeing it in the ghat forests of Dakshina Kannada its present occurrence to the North of Kodagu district needs confirmation. Even in Kodagu it is frequently shot by Apiary keepers as it raids the beehives kept in coffee and cardamom plantations. Very little is also known about the present status of the ratel or honey badger whose nominal distributional range covers the entire State except the West coast/Western ghats. A wild caught specimen from Srinivasapura area of Kolar district in 1974 lived in the Mysore Zoo for a short time. All these three rare Mustelids need urgent and specific conservation efforts in the State.

Elephants and other Ungulates

The distribution of the elephants in the State is relatively better known (Nair and Gadgil 1978). The official Census estimates the elephant population at 3579 animals. This also may be an overestimate due to multiple counts of herds and other methodological problems. However, a substantial elephant population exceeding 1000 animals occurs in the Nagarahole, Bandipur and Biligirirangan sanctuaries. Adjacent Kollegal hills and Kaveri valley also support additional large populations. The populations along the Western ghat slopes in Kodagu, Hassan, Dakshina Kannada, Chikmagalur, Shimoga, and Uttara Kannada are small, disjunct and occupy a highly fragmented habitat (Nair and Gadgil 1978) and their long term viability is doubtful. Bhadra wildlife sanctuary has an almost isolated population of 60 + elephants.

Karnataka is the stronghold of gaur. Large populations of 1000 + each exist in Nagarahole and Bhadra sanctuaries. Substantial populations also occur in Bandipur, Biligirirangans and the Western ghat crest line.

Nilgiri tahr does not occur in Karnataka now. Whether its past distribution extended to Brahmagiris and Biligirirangans, where apparently suitable habitat exists needs to be investigated, since there are unconfirmed local reports indicating such a possibility. The present distribution of the chinkara is also unknown. But reliable observers mention its presence in Sandur, Bellary district (M. Y. Ghorpade, personal communication) and past occurrence near Kadur (K. R. Sethna and J. Van Ingen, personal communication) and in Gulbarga district (D. K. Deshmukh, personal communication). I have seen a female captive specimen obtained from an unknown locality in Northern interior Karnataka about 10 years ago.

Blackbuck occur in scattered localities of both Northern and Southern plains. A large population exceeding 2000 animals exists in Ranebennur sanctuary and adjoining areas. An interesting observation is that plantations of *Eucalyptus* raised in several barren localities (Ranebennur, Byadagi and Guttal in Dharwar district, Omkara-Naganapura in Mysore district) have offered some badly needed cover to these animals and their populations has grown as a result (Karanth and Singh, in press). The four-horned antelope is seen in drier parts of Nagarahole, Bandipur and Biligirirangans. It is perhaps more widely distributed than presumed, because local people often fail to distinguish it from the more common Muntjac.

In the past, nilgai was distributed right up to the Southern extremity of the State and adjacent areas of Tamil Nadu. Interestingly, Russel (1900) does not mention it among the native animals of Mysore district. It is probably extinct in Karnataka now, though there are unconfirmed reports of its occurrence upto the nineteen sixties. Karnataka forest department has just initiated a project to reintroduce captive bred Nilgai into the wilds in Bannerghatta National Park area.

Birds

Among birds, the Great Indian Bustard (*Choriotis nigriceps*) occurs in Ranebennur sanctuary and probably in Bellary and Gulbarga areas on the Northern plateau. In the Southern plateau region a sub-adult male, illegally caught in Yediyur area of Tumkur district is now in Mysore Zoo. Reliable informants have also reported bustard sightings from Bukkapatna (Tumkur district), Jakkahalli-Nagamangala (Mandya district) and Dasana Koppalu (Mysore district). The bird is known as "Yeraloddu' and "Dorvayana Hakki" respectively in Northern and Southern parts of the State. Migrant white storks (*Ciconia ciconia ciconia*) were sighted by me in two localities in Mysore district recently. Grey pelicans (*Pelecanus philippensis*) regularly breed in Kokkare Bellur (Mandya district).

Rangana Thittu and Kokkare Bellur (Both in Mandya district) and Mandagadde (in Shimoga district) are the well known water fowl breeding protected sites in Karnataka. The backwaters of Kabini reservoir located between Bandipur and Nagarahole National Parks also shelters large water bird congregations.

Reptiles

Marsh crocodile (*Crocodilus palustris*) occurs in the Kaveri river in Rangana Thittu and also in Nugu, Kabini and Bhadra reservoirs. On the West coast more than 10 sea turtle (mainly Olive Riddley) hatching areas have been located, where the forest department has already initiated a turtle conservation programme (M. K. Appayya, personal communication).

CONSERVATION

Wildlife Protection

Normally poaching of wild animals is carried on by three classes of people: (i) local villagers for own consumption; (ii) traditional hunting tribes such as Hakki Pakkis for own consumption and sale; (iii) urban/semiurban hunters for 'sport' and trophies; (iv) specialised professionals like ivory hunters. Until the early 1970s poaching by all these categories was rampant in Karnataka. With the introduction and enforcement of the Wildlife Protection Act since 1974, the blatant poaching of earlier years has been gradually curtailed. Day time hunting in reserved forests with the help of dogs, public display and parading of trophies have all virtually come to an end. The poaching that goes on is essentially surruptious though still widespread. Every year probably more than a fifty poaching offences are booked by the forest department. The sport hunting by urban poachers has declined most, followed by pot hunting by villagers, within the reserved forests. The poaching in farms, estates and non-reserved forest areas is still substantial and most professional hunting tribes operate in these areas.

Poaching of elephants for ivory by organised gangs is however a serious problem. There have been several instances of exchange of fire between forest protection staff and ivory poachers, resulting in casualities on both sides. Illegal dynamiting of rivers for fish, which also kills other aquatic animals like crocodiles and otters, also continues to be a problem in the absence of effective laws.

Inadequate funds and staff, poor housing, equipments, ammunitions and other facilities are the major constraints in improving the present levels of protection.

The total ban on hunting (including licenced hunting) in the State for over ten years continuously has been very helpful to the wildlife protection staff in booking offenders who do not have any legal loopholes for escape.

Problems of Conserving Habitats

As elsewhere in the country Karnataka also faces serious problems in conserving the remaining wildlife habitats. The pressures that threaten the State's wildlife habitats originate from the efforts to meet the basic and developmental needs of a growing human population. Without trying to be exhaustive, in this section, I have tried to highlight some of these threats to conservation of wildlife habitats in Karnataka.

Conversion of Habitats to Agricultural Use

This is perhaps the single most destructive cause as large extents of forests, woodlands, wetlands and savannas outside the reserved forests which are administered by the Revenue department have been continuously converted in to farm lands through encroachments and land grants. While it is difficult to estimate the extent of such threatened habitats, the fact that about 40,000 hectares of reserved forest area alone is under illegal encroachment in the State highlights the magnitude of the problem. In Chikmagalur district alone moist deciduous and semi evergreen forests exceeding 5000 hectares are being parelleled out to cultivators by the revenue authorities, to cite just one example. All the mangrove ecosystems in Karnataka coast are likely to be similarly lost.

Habitat Loss Due to Large Developmental Projects

Large projects for irrigation, power generation, mining and railway lines have also caused substantial loss of habitats in the last three decades. An estimate puts this habitat loss in reserved forests alone at over 200,000 hectares between 1956 and 1983 in Karnataka (Anon. 1984). Some of the notably damaging projects in the past have been Kalinadi and associated projects in Uttara Kannada, Sharavathi project in Shimoga, Bhadra project in Chikmagalur, Kabini project in Mysore district for power generation/irrigation. Similarly, mining projects in Kudremukh, Sandur and Kollegal hills and the Hassan-Mangalore railway project have been some other large projects with severe accompanying habitat destruction.

Proposed Upper Bhadra, Upper Thunga and Barapole irrigation projects are also potentially capable of substantial damage.

Habitat Degradation Due to Local Factors

Excessive removal of firewood, small timber, green and dry leaf manure as well as cattle grazing and fires caused by local village communities in and around the forests have already resulted in the gradual but substantial degradation and fragmentation of wildlife habitats. Such biotic pressures have almost entirely eliminated the original plant communities in almost all the dry zone areas of the State (Shyamsunder and Reddy 1986).

The efforts of various developmental agencies of the government to deliver social services like electricity, roads, telecommunications, transport and education to human settlements honeycombing the forests are also fragmenting and degrading the wildlife habitats.

Habitat Damage Due to Forestry and Allied Activities

Forestry practices in the State have also in the past contributed to the habitat damage. The earlier practice of clearfelling extensive stands of moist forests for raising plantations of teak and rubber has significantly altered the original habitats. Clearfelling of dry forests under some silvicultural prescriptions resulted in similar damage. The impact of long rotation selection felling on wildlife is hard to assess in the absence of any good studies in the tract. While there is some evidence that such logging might even improve the habitat for some ungulates, the negative consequences like disturbance, road building and rapid spreading of exotic weeds like *Eupatorium* usually associated with selection felling cannot be ignored.

Large scale collection of minor forest produce like canes, fruits, nuts and barks of various tree species either by tribal cooperatives or others is also another factor likely to gradually alter the composition of the habitat and deny critical food resources to some wildlife species, particularly in wet evergreen forests.

In summing up the impact of all the problems of conserving habitats, it appears as though activities of local communities are the dominant cause of habitat damage in the dry zone and lower levels and peripheries of the moist zone habitats, and large developmental projects as well as forestry related activities are additional degrading factors at higher elevations and in remotely located wildlife habitats of Karnataka.

Protecting the Habitats

Inspite of many negative factors outlined above, some positive steps have also been taken in recent times by the State government

TABLE 2

NATURE RESERVES IN KARNATAKA

Sl. No.		Area km²	Habitat types	Protection status
1.	Bandipur National Park	874	Moist and dry deciduous forests	Adequate
2.	Nagarahole National Park	572	Moist and dry deciduous forests	Adequate
3.	Bannerghatta National Park	104	Dry deciduous (transitional type)	Inadequate
4.	Biligirirangaswamy sanctuary	324	Dry, moist, montane shola forests	Adequate
5.	Bhadra sanctuary	492	Dry, moist, semi evergreen and montane shola forests	Adequate
6.	Dandeli sanctuary	5729	Dry/moist, deciduous and semi evergreen forests	Inadequate
7.	Melkote Temple sanctuary	49	Dry-open scrub forest	Inadequate
8.	Mookambika sanctuary	247	Coastal deciduous, semi evergreen and medium elevation evergreens	Inadequate
9.	Nugu sanctuary	30	Degraded dry deciduous	Inadequate
10.	Sharavathy valley sanctuary	431	Evergreen, semi evergreen and moist deciduous forests	Inadequate
11.	Shettihally sanctuary	395	Dry/moist deciduous and semi evergreen forests	Inadequate
12.	Someshwara sanctuary	88	Evergreen/semi evergreen forests	Inadequate
13.	Ranebennur sanctuary	119	Eucalyptus plantation	Adequate
14.	Arabi Thittu game reserve	13	Degraded deciduous forests	Inadequate
15.	Ghataprabha bird sanctuary	29	Foreshore of reservoir	Inadequate
16.	Adichunchanagiri sanctuary	0.8	Temple surroundings	Adequate
17.	Ranganathittu bird sanctuary	0.67	River and islands on Kaveri	Adequate
18.	Mandagadde bird sanctuary*	—	River and islands on Thunga	Adequate
19.	Kokkare Bellur bird sanctuary*	—	Village premises	Adequate
20.	Brahmagiri sanctuary	181	Evergreen forests	Inadequate

* Not officially gazetted as sanctuaries.

to alleviate some of these problems. These are listed briefly here below:

1. In 1975 the executive wing of the State government shed its own powers to release reserved forests for agricultural use and vested it in the legislature. A similar All India measure (The Forest Conservation Act, 1980) came in to force only six years later.
2. In the 1974-1977 period, the grossly misused privilege of allowing people to take carts in to forests ostensibly to collect 'dry wood' under prepaid licences was stopped. Powers to evict encroachers and confiscate vehicles used in forest offences were given to forest officers.
3. In the 1974-1980 period the practice of clearfelling natural forests for monoculture plantations was stopped. Even under selection felling the intensity of exploitation was considerably reduced. As a result of these conservation measures the annual production of firewood and timber from reserved forests declined by 52% between 1975 and 1983. (Karanth 1985).
4. In 1976 a major afforestation programme was drawn up by the State forest department to raise plantations in unwooded and barren areas to meet the growing needs of fuel, timber and industrial wood. Though this plan was rejected by Government of India, later in the 1980s a substantial social forestry project was launched with the World Bank assistance to meet fuelwood/timber needs.

Nature Reserves in Karnataka

Karnataka has 3 National Parks and 14 Wildlife Sanctuaries which cover 9900 km^2 or 26% of the total reserved forest area (5% of the geographical area) of the State. These figures are, however, misleading because Dandeli wildlife sanctuary, which is virtually unprotected and includes a large part of Uttara Kannada district accounts for 5700 km^2 or 58% of the area under nature reserves. Actually, apart from Nagarahole, Bandipur, Biligirirangans, Bhadra and Ranebennur, other notified nature reserves are merely reserved forests with no extra efforts on wildlife protection. Moreover, in terms of biogeographic representation also, the existing nature reserves tend to overrepresent deciduous forests while inadequately serving all other biomes/habitat types. Table 2 shows the existing nature reserve areas, habitat types represented and status of wildlife protection in them on a subjective scale.

To overcome these drawbacks, the state wildlife advisory board has recommended rationalisation of the nature reserve network by the addition of some unrepresented/under represented habitat types and deletion of unviable areas and over-represented habitats. If these proposals are accepted by the government many of the diverse plant and animal communities in the State will receive protected area status. But some of the habitats like mangroves, thorn scrub and dry evergreen vegetation might already be eroded beyond the levels needed for providing adequate sized reserves.

SUMMARY AND CONCLUSIONS

Since 1974 several positive measures have been implemented to improve the conservation status of wildlife and habitats in Karnataka. Large areas have been declared as protected areas. Antipoaching measures have been reasonably effective at least in some nature reserves like Nagarahole, Bandipur, Biligirirangans, Bhadra and Ranebennur. In general there has been probably a decline in the levels of poaching in the reserved forests all over the State when compared to the earlier two or three decades. Schemes for provision of monetary compensation to farmers for life, livestock and crops lost due to wildlife are also operating reasonably well. Forestry activities has been considerably curtailed as a conservation measure.

However, many problems still need to be overcome. Existing nature reserve system does not represent all wildlife habitat types and biomes. The paucity of funding, staff, equipment and infrastructural facilities have resulted in wholly inadequate levels of protection in many notified nature reserves. Even the better funded reserves like Bandipur, Nagarahole, Bhadra and Ranebennur are managed on an adhoc basis without any coherent wildlife management concepts or plans. On a broader scale, conversion of wildlife habitats to agricultural use by the revenue department, large developmental projects, leases for extraction of plywoods and for cultivation and fragmentation/destruction due to developmental activities pose long term threats.

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BLACKNECKED CRANE (*GRUS NIGRICOLLIS*) IN LADAKH — 1986

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Eric D'Cunha[1]

(*With three colour plates*)

INTRODUCTION

The only alpine crane of the world, the Blacknecked Crane (*Grus nigricollis*) is an inhabitant of the high table lands of Central Asia. It nests in high-altitude lake environs of the Tibetan Plateau in summer, and affects open, fallow paddy fields and swampy land at lower altitudes in winter (Ali and Ripley 1969). It has an exclusive distributional breeding range between 3500 and 5500 m and an equally unique migratory pattern (Hussain 1985). The only wintering ground known in India is in the Apa Tani Valley of Arunachal Pradesh (Betts 1954) where the birds are now no longer seen.

It is now known that only the south-western periphery of the Blacknecked Crane's breeding range lies in Ladakh and larger, more suitable areas exist in Tibetan Plateau. Recent information from China indicate that the bird is not as rare as it was believed and large numbers of them breed there. Ma Yi-Ching (1982) reported large migratory flock of 300-400 Blacknecked Cranes at the Tangra Range and another flock of 600 in Tsaidan Basin, at the 18th International Ornithological Congress in Moscow (quoted by Hussain 1985). However, they continue to be very rare in Ladakh.

Inspite of several expeditions in the last 10 years only three nesting sites with one pair of cranes each were positively identified in eastern Ladakh. So far no scientific expedition has reported sighting more than a dozen cranes in the region. Very little was known about the habits and habitat of the Blacknecked Crane. In fact, no information was available on their ecological requirements, rearing of the juveniles and intraspecific relationships.

Due to unavoidable technical reasons we could not reach Ladakh early enough to study the actual nesting of the cranes and geese. After acclimatisation at Leh, four of us went to Chushul on 1 August, 1986. Three returned to Leh after 25 days while Asad Akhtar stayed on till the end of the studies on 12th October. Eric D'Cunha visited Tso Moriri, Tso Kar, Fukche-Kuyul and Staglun in the second half of September while Goutam Narayan and Lima Rosalind went to Hanle and also visited Chumur between mid-September and early October.

The study areas were reached by Army, ITBP or private supply trucks. Locally, we moved either on ponies or on foot. A district administration jeep was made available to us for three days and it was used for survey of Tso Moriri and Tso Kar areas.

The areas visited during this study fall under the Chatang subdivision of Ladakh region. Situated in the south-western extremity

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of the Tibetan Plateau, it is characterised by arctic wind-swept desert and barren hills where marshes and sandy plains occur on more or less flat, high altitude tablelands amidst rugged terrain and lofty mountains. The area also has numerous small freshwater lakes and a few large brackish lakes of varying salinity and depths. The sandy valleys are drained by tributaries of the river Indus.

Ladakh supports scanty vegetation. Annual and very few perennial weeds are seen in the places that retain moisture. The banks of lakes and streams and the marshy areas are ideal for the growth of grasses, shrubs and other flora in summer. Most plants are alpine mesophytes.

The most singular character of the climate of Ladakh is the dryness which is of two kinds: physical due to paucity of precipitation during the summer and autumn, and physiological caused by sub-zero temperature inhibiting absorption of water by the plants in winter and early spring when the precipitation occurs. (Sapru and Kachru 1976).

The soil is mainly sandy or sandy-loam with appreciable quantities of clay in the marshes. The soil pH ranges between 7 and 11 (Bhat 1965). Borax deposits in the dried marshy areas and around lakes is quite common.

THE SURVEY

1. PANGONG TSO (1, 18, and 25 August, 11 September, 12 October)

We reached the western end of Pangong Tso at Lukung shortly after noon on 1 August 1986, on our way to Chushul. At Lukung a few Brahminy Ducks (*Tadorna ferruginea*) and Brownheaded Gulls (*Larus brunnicephalus*) both with juveniles, were seen. We also found hundreds of dead and dying fish (*Noemacheilus* sp.) on the edge of the lake, probably carried into the salt lake from the glacial streams.

Thakum was visited on 19 August between 1100 and 1500 hours. More than 35 Barheaded Geese, few Common Mergansers (*Mergus merganser*) with juveniles, a few hundred migratory ducks (*Anas* spp.), 3 Large Cormorants (*Phalacrocorax carbo*), Common Terns (*Sterna hirundo*) and Brownheaded Gulls were noticed on the shore of Pangong Tso. Brahminy Ducks, Common Redshanks (*Tringa totanus*), and Terek Sandpiper (*Tringa terek*) were seen in the marshy area (grazing ground) next to the lake. Thakum was visited again on 11 September when live amphipods were collected from the lake shore. Ducks and geese were not seen on this day. Two more journeys along the lake on 25 August and 12 October did not reveal anything new.

2. CHUSHUL (1 August to 12 October)

We saw a pair of flying Blacknecked Cranes as soon as we entered Chushul on 1 August afternoon. This was a pair of non-breeding subadults seen regularly in the Shaley marsh and surrounding areas till the end of the study. The breeding pair of adult cranes with two juveniles were located in the Demik marsh — Chhonyak area of Chushul on 4 August and were kept under regular observation till 12 October by which time the young birds were adept at flying and were moving far and wide in the Chushul plains with their parents. This family was seen using Demik as well as the Shaley marsh closer to the village after 20 September, when they encroached upon the home-area of the non-breeding pair.

In addition, a few more adult pairs of cranes were recorded intermitently during our 72 day stay at Chushul. On 15 August afternoon a pair of adult cranes were noticed at Shigul Tso and they stayed there for about 24 hours before soaring across the mountains in north-eastely direction. On 23 September a pair of adult cranes were seen again in the Demik marsh while the family with juveniles and the subadult paid were foraging in the Shaley marsh only 2-3 km away. This new pair was noticed a few times either in the Demik or at Shaley till 27 September. Later, a pair of cranes were reported from Shigul Tso on 2 October morning but were not seen during afternoon visit. On 10 October, four adult cranes were seen foraging together at Tsirding, 4-5 km east of Demik. Thus about 5 more pairs of crane were recorded from Chushul in addition to the family of four and the sub-adult pair. It is possible that the 5 pairs were different but we cannot be certain.

A pair of Barheaded Geese raised their three goslings in Shigul Tso. This family was not noticed after 26 August. A flock of six Barheaded Geese including four juveniles visited Demik on 15 September afternoon.

Brahminy Duck pairs with good number (upto 13 with a pair) of juveniles and Common Tern with young on the nest were observed at Shigul Tso. These birds were also seen at Chhonyak — Demik. Garganey Teals (*Anas querquedula*) were seen at Shigul Tso in early August. Other birds using the marsh and lakes for breeding were Brownheaded Gulls, Common Redshank, Common Sandpiper (*Tringa hypoleucos*), Lesser Sand Plover (*Charadrius mongolus*), Short-toed Lark (*Calendra cinerea*), Longbilled Calendra Lark (*Melanocorypha maxima*), Horned Lark (*Eremophila alpestris*), Desert Wheatear (*Oenanthe deserti*), Robin Accentor (*Prunella rubeculoides*), Yellowheaded Wagtail (*Motacilla citreola*), Grey Wagtail (*Motacilla cinerea*), Pied Wagtail (*Motacilla alba*), Tibet Snow Finch (*Montifringilla adamsi*), Himalayan Mountain Finch (*Leucosticte brandti*), Hodgson's Mountain Finch (*Leucosticte nemoricola*) and Eastern Great Rosefinch (*Carpodacus rubicilloides*).

3. TSO MORIRI AND KYAGAR TSO (12 September)

The lakes were visited to survey the breeding sites of Barheaded Geese. Several Brahminy Ducks and few Brownheaded Gulls were seen at Kyagar Tso, while none were seen in Tso Moriri near Karzok village. Villagers reported that many Barheaded Geese ('Nangba') and Brahminy Ducks ('Nguru') arrive at the lake as early as April, and by end of August all leave with their fledglings. In summer the birds are reported to cause considerable damage to crop fields in the village.

4. TSO KAR AND STARTSAPUK TSO (13 September)

No crane or goose was sighted at Tsokar. However, a few Barheaded Goose feathers were collected from a few mounds and small islands. More than 125 Brahminy Ducks with about 60 juveniles, about 30 young and adult Great Crested Grebes (*Podiceps cristatus*), a Whimbrel (*Numenius phaeopus*), two Grey Herons (*Ardea cinerea*) and some common smaller birds were noticed at Startsapuk Tso.

5. HANLE (15 to 30 September and 3 to 6 October)

A family of Blacknecked Cranes with two juveniles were sighted on our first day, 15 September 1986, at Hanle. They were foraging in the Yung Temo marsh near Tara gompa close to grazing sheep and goats. They became alarmed and moved away on our approach in normal attire. However, we were able to study them later when we started wearing the Ladakhi dress 'goncha'.

The family was kept under regular observation upto 30 September and then again from 3 to 6 October. The young were seen running flapping wings and even flying for short distances low over ground soon after our arrival. By the time we left Hanle they could fly for longer distance with their parents.

The nesting site of this pair was inspected on 22 September, when the 'numberdar' of Khaldong village who had seen them nesting and raising the chicks, showed it to us. They had nested on a small flat mound in the middle of a tiny and very shallow pond in Bukh area about 4 km south-east of Khaldong village. One had to wade through water and soft mud to reach the mound from where pieces of egg shells were collected. No nesting material was found. The Bukh area is 8 to 10 km away from Yung Temo marsh where the cranes resided, and it was comparatively dry and devoid of bogs. The pools and other stagnant water bodies here were almost lifeless.

By fourth week of September it started snowing regularly, but this did not seem to affect the cranes much as they were seen foraging and moving normally after the weather cleared.

No Barheaded Goose was seen in or around Hanle. A Grey Heron, few immature Brahminy Ducks and migratory teals, Marsh Harrier, Common Redshank and snipes, Tibetan Sandgrouse, larks, swallows and Crag Martins, choughs, Raven, Desert Wheatears, wagtails, snow and mountain finches were some of the common birds seen in ths marshes at or near Blacknecked Crane habitat.

6. FUKCHE-KUYUL (17 and 21 September)

Fukche and Kuyul marshes were visited in search of a reported pair of Blacknecked Cranes. The area around Kuyul was surveyed on 17 September and those near Fukche were covered on 21 September with ITBP or Army officers familiar with the cranes (both had reported sighting cranes only in 1985), but no crane was located. The marshes in these areas were rather dry. A flock of about 40 Barheaded Geese including immature birds were seen on the banks of river Indus near Fukche.

7. STAGLUN (25 September)

Blacknecked Cranes were reported from Staglun too but a thorough search on ponies from Rango proved unfruitful. The marsh was dry with borax deposits at several places, and the grass had turned yellow everywhere. However, people from the area confirmed having seen a pair of Blacknecked Cranes ('tung-tung') earlier in the season. They were even reported to be displaying. A forest department official felt that the pair had nested here but suspected that the nest might have been washed away in rain and flood during late July.

8. CHUMUR-LAM TSANYA (30 September to 3 October)

We got the opportunity to visit these areas while staying at Hanle, and reached the Chumur-Lam Tsanya plains late in the afternoon on 30 September. The area along the stream between these two locations was thoroughly surveyed during the next two days. The huge marsh and sandy plain north of Lam Tsanya extending upto Lam Tso was carefully scanned from a hill using a telescope but no crane was seen. The Tibetans at Lam Tsanya reported that the Blacknecked Cranes are usually seen only in April-May. Presumably, the cranes on their south-west passage in autumn stop in the area for sometime. The marshes, except those along the streams and springs, had dried up by the time of our visit.

An ITBP officer returning after a reconnaissance in Lam Tso area reported sighting a single Blacknecked Crane on 1 October, however, this could not be confirmed. Due to non availability of transport or ponies we could not visit Lam Tso proper.

THE CRANE HABITAT

The families of Blacknecked Cranes at Chushul and Hanle usually remained in boggy marshes frequenting the streams and pools, and rarely venturing away from water and greenery. The lake at Chushul where the pair had originally nested on a tiny island, had plenty of vegetation. The bogs at both places consisted of numerous tiny mounds of earth in submerged flat country, some of the mounds being free floating. The fresh water streams and pools were shallow with very soft mud at the bottom.

FLORA

The short spring and summer seasons in Ladakh from April to October favours only short lived alpine plants.

In August the grasses, herbs and shrubs grew luxuriently on the mounds while some submerged vegetation occurred in still waters. Most of these were flowering.

Ranunculus pulchellus, Potentilla anserina, Oxytropis microphylla, Gentiana leucomeleana were some of the most common plants in the marshes. *Equisetum ramossimum* and *Utricularia minor* grew in stagnant pools and lakes. In Chushul, a reed *Ranunculus flavidus* was in its flowering peak in the lake. The five species of sedges of the family Cyperaceae collected from the marshes are yet to be identified. The Blacknecked Cranes were seen tugging at their roots and shoots. By September the grasses had turned golden-yellow. Some of the bog mounds had a thick undergrowth of moss which retained moisture and these sustained the green grass even after they had dried up at other places.

The plants collected are listed in Appendix I.

FAUNA

The flowing water teemed with fishes while the stagnant water abounded in planktonic life. Amphipods, small fishes, and snails occurred in running as well as in more or less still water. Water bugs and beetles were found in still water pools.

Schizopygopsis stoliczkae, Ptychobarbus conirostris and *Noemacheilus* spp. were the commonly found fish in the streams and pools where the cranes foraged regularly.

Along the edge of inundated areas the Quetta Voles (*Ellobius fuscocapillus*) were abundant. They nibbled the grasses and burrowed in soft earth making intricate system of tunnels with multiple openings. In drier sandy and pebbly areas around the marshes the Toad-Agamas (*Phrynocephalus theobaldi*) were common.

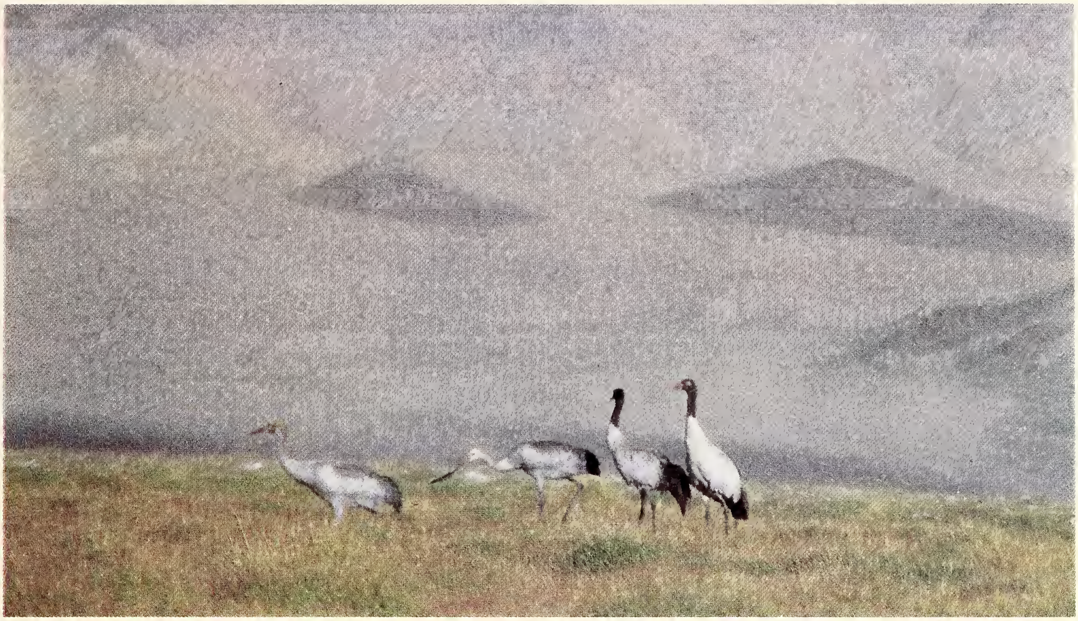
Grasshoppers (*Acrydium* sp.) were found in the meadows and they also strayed occasionally to bordering marshes. The cranes spent some time in the meadows and dry sandy areas specially while crossing over from one patch of the marsh to other and also while training the young to fly.

The birds associated with crane habitats has already been noted under findings of survey at Chushul and Hanle.

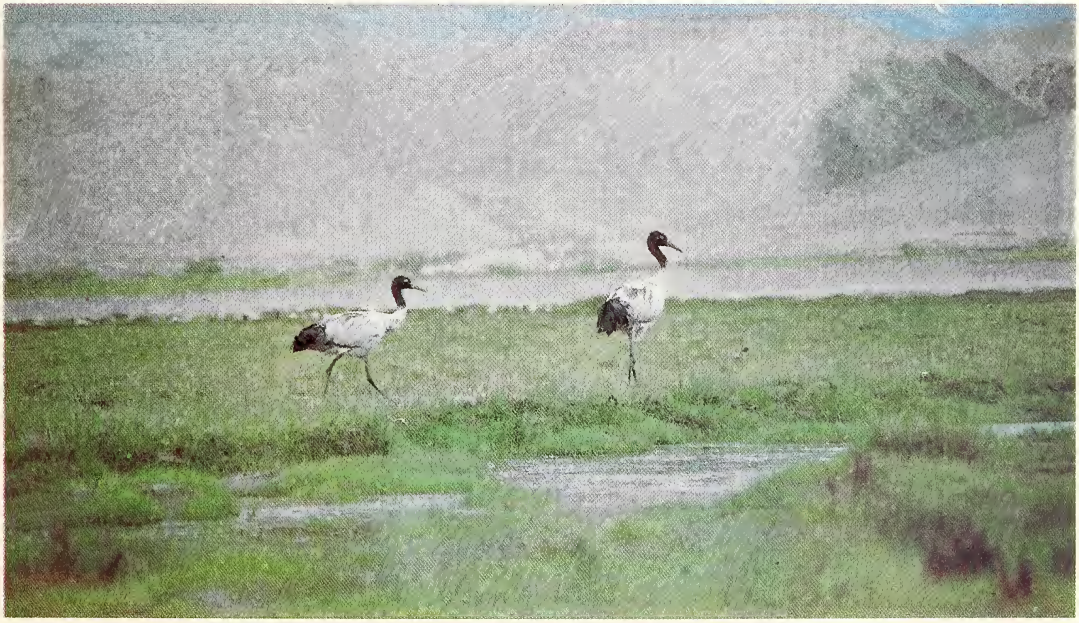
A complete list of birds and animals recorded is given in Appendix II.

EXTERNAL FEATURES AND BEHAVIOUR

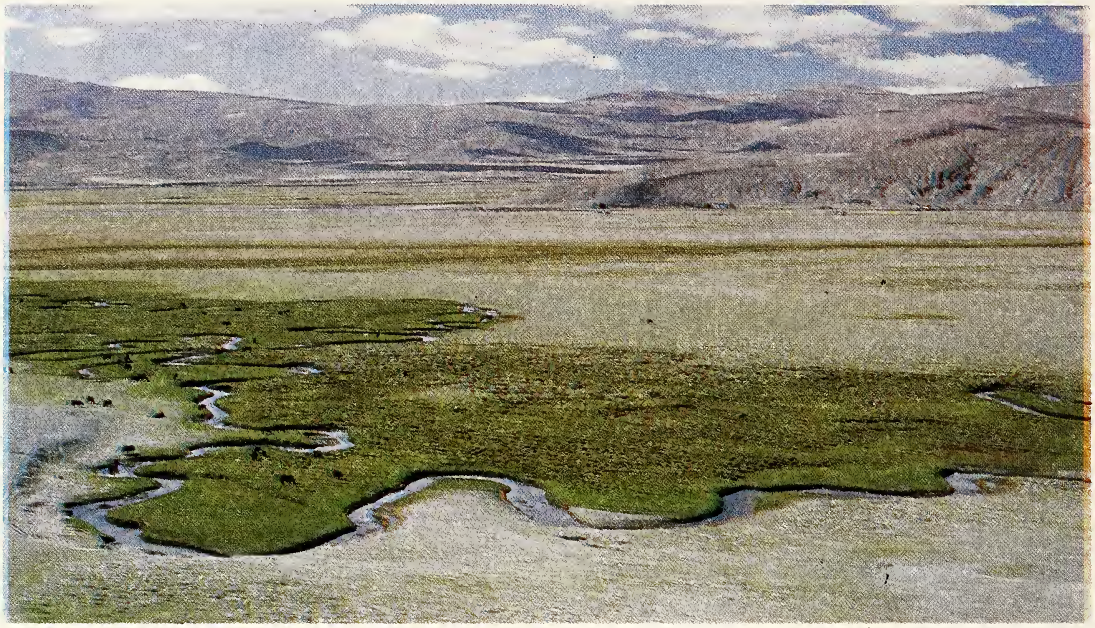
Both the families of Blacknecked Crane at Chushul and Hanle had a pair of juveniles each and their ecology and behaviour were studied. At Chushul, a pair of subadults (determined by prominent greyish brown feathers



The family of Blacknecked Crane at Hanle in September. Juvenile struggling with a fish too big for it to swallow.



The subadult Blacknecked Cranes at Chushul. The vegetation in the marsh is much greener in August.



View of a portion of Hanle marsh and plains. The cranes had nested near the base of the hills in the background.

The Hanle plain after snowfall in October.

on their upper back and lighter colour of their black necks compared to the adults) were also studied.

MORPHOLOGY OF JUVENILES

When the cranes at Chushul were first seen in the beginning of August, the juveniles were almost two months old and stood about three-fourth of the height of the parents. One of the young was slightly larger than the other. The juveniles were overall greyish buff with lighter crown. Initially the necks were downy and even the primaries were light in colour. The tail had just begun to grow.

When we reached Hanle in mid-September the juveniles were more than three months old and only a little smaller than the adults. By then these as well as the juveniles at Chushul had grown prominent tail feathers and their primaries had darkened. A dark patch had developed in the centre of the closed wings. The neck was no longer downy and had become greyish, while the crown was yellowish buff.

By the end of September, the juveniles were almost as tall as the adults but thinner. The tail feathers were dark grey, the upper tail coverts greyish white, primaries and secondaries almost black, and the upper wing coverts had become darker. The neck too had darkened slightly and the crown was yellowish-pink, while the bill had acquired an orangish hue. The overall body colour was still grey.

ACTIVITY AND LOCAL MOVEMENTS

Most of the daylight hours were spent in foraging by the Blacknecked Crane families. Preening and keeping watch were other major activities of the adult cranes, while resting by squatting on the ground as well as preening occupied a good amount of time for the juveniles. Adults rarely rested during the day. The cranes moved effortlessly through the treacherous bogs.

Time spent in foraging resting and preening varied considerably. Often the family or the subadult pair foraged exclusively for upto two hours moving slowly from one spot to other, and occasionally spent considerable time in other activities while foraging. The time of the day did not seem to affect their activity.

Movements

While foraging the cranes kept moving slowly from one spot to other, but at times they walked briskly for long distances without feeding. When they moved without foraging the juveniles usually followed the adults, but occasionally the bigger juvenile took the lead. At times, this initiative of the juvenile often caused it to be left behind, when the adults decided to change course without its knowledge and it had to run to catch up with them again.

The crane thus covered several kilometres in a day, sometimes however, they remained stationary or moved very little for several hours.

In August, the family at Chushul remained around the lake and in Demik marsh where the adults had nested. The subadult pair moved over large areas of Chushul marshes, sometimes by flying between Shaley and Demik or other areas.

Occasionally, the families at Chushul and Hanle were seen engaged in a sort of flight-training for the juveniles, in which a lot of running and flapping of wings and later, even low flying was involved. When the young became capable of flight the family too started travelling far and wide in the course of a day.

The family at Hanle resided in a portion of the marsh about 8 to 10 km away from the nesting site, and in a day moved up and down a 3 to 4 km long stretch of the plain.

The families foraged even after sunset, and often remained in more or less the same patch of marsh the next morning. Thus it is assumed that they roost at or near the foraging sites selecting a safe mound or island in the bogs or lake. This has to be checked.

WARINESS

The adult cranes usually kept careful watch for approaching danger. They were generally wary of people not in the local dress. They were not scared of the local shepherds and were quite unperturbed by the livestock; they kept away from the shepherd dogs. However, the cranes with young (2 month old) juveniles at Chushul were extremely wary even of the locals. They started moving away with the young making short and subdued alarm calls ("kurr") if anyone reached even a kilometer from them. Once the family moved out of the marsh and climbed upto about 50 m on the steep hill slope near by. On that day, one of the juveniles hid somewhere in the marsh, but later it was located by the parents calling frequently and led up the hill slope.

As the juveniles grew older and became capable of running and flying the family allowed closer approach by the observers and they also began foraging in marshy areas close to the village where many livestock grazed. The family at Hanle with grown up juveniles was not very wary. They often foraged among the grazing livestock close to the crowded monastery. We could watch without disturbing them from about 250-300 m and could slowly creep up to even 50 m from them before they became troubled and moved away. When suspicious, one of the adults usually kept constant watch while others foraged. This adult preened often and raised the alarm if the danger got closer.

In August, the subadult cranes at Chushul were much less wary than the family. They usually foraged in the marsh close to the road leading to the village. In Ladakhi attire one could go upto 200 m without disturbing them. Although they were used to the locals, they did not mind people in other attire either. This pair foraged close to the hot springs in Shaley even as a crowd of locals washed there. According to the villagers, as the winter sets in the cranes move to within 50 m of the hot springs. On our last day (12 October) even the family of four was seen foraging near the hot springs. However, the significance or true reasons behind this behaviour is not understood.

FOOD AND FORAGING

Most of the crane's time in its daily routine is spent in foraging, wading through the marshes or along the edge of shallow pools and lakes. Moving effortlessly through the bogs, ditches and mounds they feed from the ground, water, or soft mud. Usually they foraged at one spot for a period from a few seconds to several minutes tugging at the vegetation, probing the mud often immersing the head, sometimes coming up with water dripping or vegetable matter dangling from their muddy bill or head.

The cranes also caught fishes regularly from the streams or the slowly moving waters of the marsh. In fact, the cranes with juveniles mainly fed the young on fishes. They fished like herons, stalking, aiming and jabbing to come up with glistening fish in the bill. Sometimes they even ran to catch some moving prey from ground or water.

By their movements it is apparent that the crane must also be feeding upon insects in grass (mostly grasshoppers) as well as amphipods, snails, bugs and beetles from water. Rarely, they also pecked after turning cattle dung.

The cranes with their young juveniles reportedly also caught Toad-Agamas probably because the fish may not be available in early June. It is possible that they preyed upon Quetta Voles which are numerous in the Crane foraging areas. The voles came out during day to nibble at the grasses and pick up fallen seeds near their holes, but they are so alert and agile that the cranes would have to be extremely fast and skillful to catch them.

The other cranes noticed at Chushul usually foraged in a pair close to each other. The subadult pair caught fishes less frequently than the adults of the family and they also frequented the meadows and drier areas more often.

Rarely, the adult cranes drank from stream or pool by sipping and tilting their head backwards, pointing the bill upwards to swallow.

Adult-Juvenile Association

Juveniles usually accompanied the parents who regularly offered food to them, but they also foraged independently in the same manner as the adults. The family often paired off in two adult-juvenile parties foraging at a distance of 5 to 200 m from each other. Sometimes, both juveniles foraged together or with one of the adults. At times, all four foraged in a compact group or independently. Presumably they congregated only when sufficient amount of food was found at one spot, otherwise foraging in two groups or separately to optimise effort. The independently foraging juveniles often rushed to the adult if the latter caught some favoured item like fish which was offered to the young either by placing it on the ground or directly to their bill. Occasionally, the second adult of the family also moved to the area where the other adult seemed to have found a good feeding ground. In a few instances the foraging adult gave the contact call to attract the young. The juveniles, sometimes had to beg for food.

FLIGHT

The subadult pair were occasionally seen flying low over the marshes and sandy plains, but the adults with family never flew till the juveniles were also able to fly. Even if someone approached close they relied on their legs to move away.

Flight Training

By late August the juveniles began flapping wings and running often after being induced by similar behaviour of the adults. By mid-September they could fly for short distances (approximately 100-200 m) and by the first week of October the young were able to fly for longer distances with their parents.

In later part of flight training the young seemed more keen and they initiated flapping and when the adults also flapped and ran, they followed. When they were able to get airborne the juveniles continued flying even after the adults had stopped, thus overtaking them in the process. When the juveniles finally stopped the lagging adults ran and caught up with them. They covered a distance of about 500 m in the process, flying for several seconds very low above ground.

Soaring

A pair of fully adult cranes who remained in Shigul Tso at Chushul for about 24 hours on 15-16 August were seen soaring. After being chased by flocks of Brahminy Ducks, the cranes flew and on reaching the base of a hill nearby they started circling and gaining elevation without flapping wings. In less than 4 minutes they reached a height of about 500 m to cross the hill. They kept circling higher and in the next 4 minutes were just under the clouds probably more than a kilometre above ground. Soon they were out of sight as they climbed still higher and moved towards north-east.

INTRASPECIFIC BEHAVIOUR

Communication

No unison call was heard during the study period. The cranes usually remained silent. The adults with juveniles, however, produced some short, subdued calls. When alarmed they alerted the youngs with frequent nasal "kurrr". A similar call was used to keep contact specially while moving and also to attract the attention of the juveniles when the adult got some prized catch.

Once, when the family was foraging in the territory of the subadult pair, the parents uttered the above call. The juveniles near-by interrupted foraging and came closer to the parents, with their necks drawn in. Surprisingly, the subadult pair foraging about 200 m away also came and joined the family, thus creating a commotion with all the cranes prancing around. Finally, the subadults took off and landed several hundred metres away. This gives rise to an assumption that the sub-adults too were offspring of the adult pair or perhaps were still young enough to respond to the call of the adults.

Agonistic behaviour

The adult cranes with the young were territorial and occupied a large area of the marsh and plains around their nesting site. They did not tolerate intrusions by other Blacknecked Cranes into their territory and were aggressive towards them. The subadult pair of cranes at Chushul moved extensively and were not possessive about their territory. Sometime, they would visit the territory of the family only to be chased away sooner or later. One of the parent birds called loudly and advanced towards the intruders in determined manner with quick steps, sometimes it even flew and landed near the instruders whence it gave threat calls rushing towards them. This usually resulted in the intruder flying away. Rarely, they had to be chased before they left. Once one of the parent birds was seen pursuing a pair of cranes in flight when it went alongside and struck the nearest bird with its wings and chased them till they were out of sight.

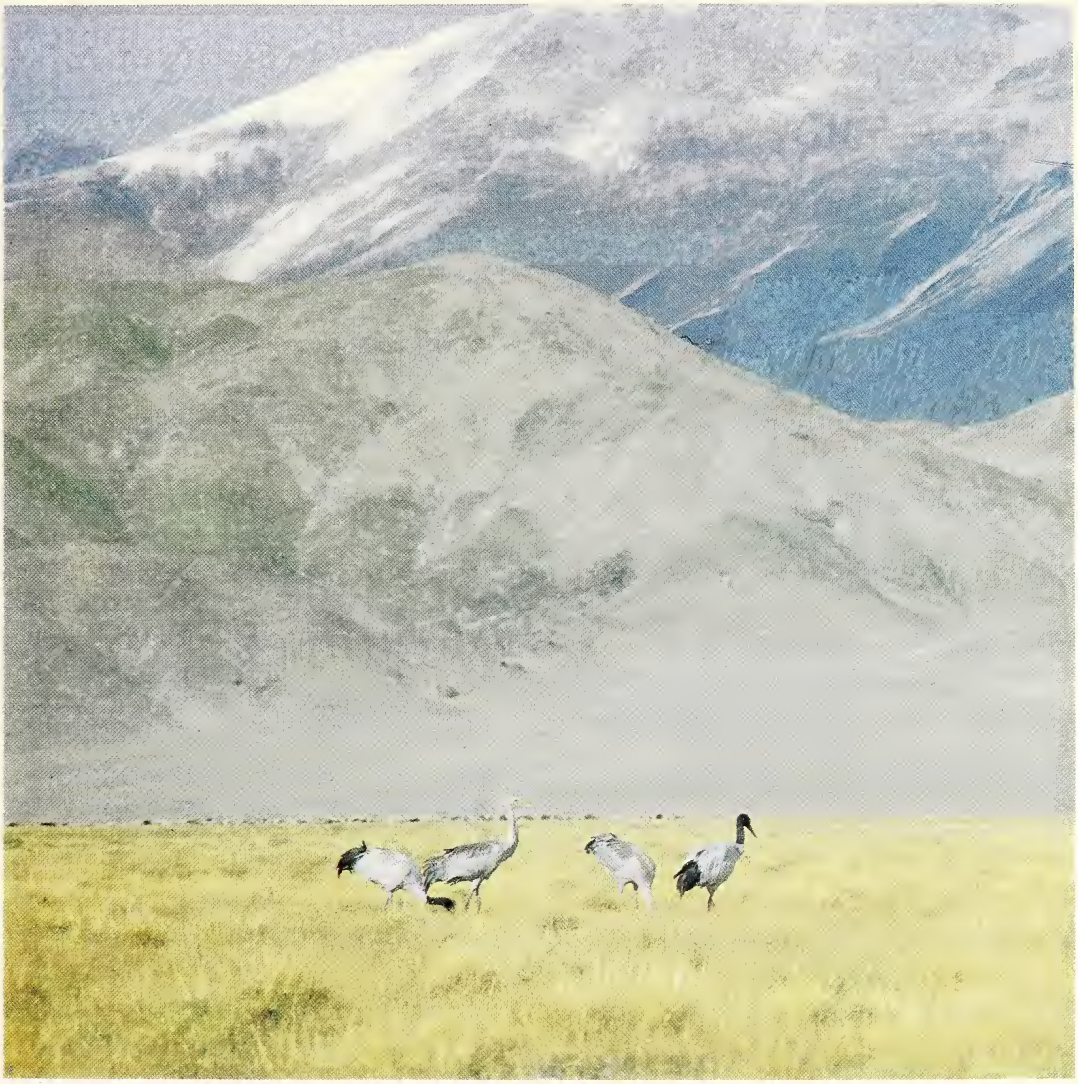
When the family encroached upon the home-area of the subadult pair of cranes, they gradually became aggressive towards the original residents and often drove them away.

INTERSPECIFIC BEHAVIOUR

The cranes did not take notice of Brahminy Ducks, Marsh Harriers and other smaller birds at their established foraging sites even if they came very close. The adults of the family at Hanle, however, drove a Grey Heron away if it came closer than 25 m. The heron curiously wanted to forage very close to the family. The cranes became alert whenever Ravens (*Corvus corax*) came to their foraging site but no interaction was observed.

The Common Terns breeding in the crane habitats were highly pugnacious and often dived at the family if they moved close to the tern nests. The cranes usually ignored them.

Once a new pair of adult cranes, who stayed at Chushul for a day, were mobbed by terns



Blacknecked Cranes (*Grus nigricollis*) in Ladakh.

on their arrival at Shigul Tso. They finally left the site after being mobbed and chased by flocks of Brahminy Ducks the next day.

The response of Blacknecked Cranes to other animals and human beings has been described under Wariness.

CONCLUSION AND RECOMMENDATIONS

PRESENT STATUS

Breeding Pairs

In the study season Blacknecked Cranes were reported from Chushul, Hanle, Fukche, Staglun and Lam Tso but they were actually sighted only at Chushul and Hanle. At both these sites a pair of cranes bred successfully and reared two youngs each till they were fully fledged. This is contrary to the belief that only one young is reared by a pair. Local enquiries revealed that rearing of two young by a pair is not uncommon. Sometimes, the adult pair reportedly even returns in the next breeding season with the previous years offspring who separate from their parents only after commencement of fresh nesting by the adults. These immature birds usually take up residence in areas close to their parents territory and are constantly chased by them if they enter the territory. The non-breeding subadults studied by us at Chushul are suspected to be such a case. Thus, it is possible that every pair coming to Ladakh may not be breeding pair, and the singletons could either be unmated or immature birds.

Non-breeding Pairs

In addition to the resident non-breeding subadults, five more crane pairs were sighted at Chushul during the study period, but it is not certain whether these were different as they were seen separately and at different times. During the survey the locals reported sighting cranes at Staglun and Lam Tso earlier in the season. A singleton was reported by ITBP officer at Lam Tso at the time of our visit. These cranes could either be unsuccessful breeding pairs or unmated birds. It is also possible that they were temporary visitors to the areas.

Nesting Sites

Blacknecked Cranes were never plentiful in Ladakh since the region lies in the periphery of the birds breeding range, and all the cranes coming to the area probably do not nest. Moreover, even at Chushul and Hanle where the huge marshes can support more than one breeding pair, this seems to have never happened. This season the Chushul pair had nested at their traditional site in Demik, while the Hanle birds nested at Bukh in the Hanle plains. No crane was sighted at Lal Pahari or Purple Mountain marsh (18 km from Hanle) where a pair had nested in 1983 (Hussain 1985). Cranes were not seen even at Tso Kar where a pair reportedly reared a young in 1982.

So far, crane nests have actually been sighted only at Chushul and Hanle inspite of reports of their nesting in other areas. During this survey suitable nesting sites were found at Startsapuk Tso near Tso Kar, Staglun, Fukche, and Lam Tsanya near Chumur. Other areas in the region may also have suitable sites and it is possible the cranes nest there. It is, however, clear that crane pairs or singletons visit many of the these places at different times between late April and November.

FACTORS AFFECTING BREEDING

Natural

One of the basic requirements for nesting of Blacknecked Crane seems to be a small mound or island in a shallow pond or lake in large undisturbed marshy area abounding in slow-flowing streams, with the pair holding a vast portion of the marsh and adjoining areas as their territory. This study has revealed that they mainly depend upon smaller fishes to feed their growing young who follow them through treacherous bogs and streams safe from human and land predators. Presence of sedges and some partly submerged vegetation is also required in their foraging site. The nests are preferably built well away from human habitation and settlements as these attract predators such as ravens, foxes and wolves in addition to harbouring ferocious shepherd dogs.

These combined with unpredictable climatic conditions controlling water supply and abundance of food plants and animals in the ecosystem are some of the factors affecting the nesting of the cranes. Thus, even if an areas appears apparently suitable for supporting one or more breeding crane pairs it may lack in some of these known and other unknown factors.

Human factor

The main threat for the cranes in Ladakh seems to be loss of suitable habitat due to increasing human and livestock population. The marshes and meadows in the crane habitat are extensively used for livestock grazing and although its effect is not fully known, there is little doubt that an unchecked growth will adversely affect the habitat. Diversion of water flow to crop fields as well as to forest department plantations may also affect the productivity of the crane habitat.

Protection

The cranes are used to physical presence of livestock and local shepherds as the Ladakhis do not disturb or harm the bird in any way. Others, however, are not so protective.

The first BNHS-WWF expedition reported removal of eggs from the nest of Chushul pair in 1976 by one of the 'jawans' stationed in the area. Gole (1981) reported that a crane pair was killed in one of the areas visited by him in 1978. During our visit we received another report of shooting of a crane pair at Hanle in 1983 by some paramilitary force personnel. These incidents have taken place after the civil, military as well as paramilitary authorities had agreed to provide all protection to the wildlife of the region.

Although the cranes had bred successfully at Chushul and Hanle this year, we did not find any one from the state department of wildlife protection on our arrival at the sites. Local enquiries revealed that even the guards posted to these places come there only at the time of short visits by higher officials of the department. Inspite of instructions from their superiors the guards at Chushul and Hanle joined us only after one month and ten days of our arrival at the sites respectively.

RECOMMENDATIONS

a. There is an immediate need for a proper detailed investigation at the known and probable nesting sites simultaneously to determine and assess the natural as well as man-made factors affecting the breeding of cranes in Ladakh. This could be done by effectively monitoring the breeding habitats from late April to November and comparing data collected from sites with successful and unsuccessful crane pairs as well as from probable sites with no resident crane.

b. Augmentation of livestock population, spread of cultivation, and plantation of trees should be carefully planned after thoroughly assessing their impact on the crane habitats. Only after determining the optimum water level in their breeding habitats, diversion of water-flow to or from the marshes and lakes should be considered.

c. The state department of wildlife protection, civil administration and the various police, military and paramilitary organisations should join hands in effectively protecting the crane habitats taking advice from the Department of Environment, Forest and Wildlife, Govt. of India, Bombay Natural History Society, World Wildlife Fund, and International Crane Foundation. The state forest department should consider stationing field biologists along with permanently stationed watch and ward staff. They could begin with recruiting guards from the villages near traditional crane breeding sites.

Similar recommendations forwarded after the BNHS-WWF expeditions in 1976 and 1983 were greeted with much enthusiasm, however, little was done towards implementing the suggestions. It is hoped that the earlier as well as these recommendations will be implemented before it is too late.

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* Listed in alphabetical order.

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APPENDIX I

LIST OF PLANTS COLLECTED

Scientific Name	Family	Habitat
Ranunculus pulchellus	Ranunculaceae	Marsh
Ranunculus aquatilis	„	Dry areas near streams
R. hyperboreus	„	Marsh
R. flavidus	„	Rocky slopes
Malcolmia africana	Brassicaceae	Sand dunes & plains
Lepidium apetalum	„	Rocky ground
Malthicola sp.	„	Sand dunes
Stellaria alsine	Caryophyllaceae	Wet edges of cultivated fields
Geranium meeboldii	Geraniaceae	Wet areas near cultivated fields
Oxytropis microphylla	Faboideae	Marsh
Astralagus confertus	„	Marsh
Astralagus sp.	„	Rocky Slope
Pontentilla anserina	Rosaceae	Marsh
Carum sp.	Apiaceae	Marsh
Artemesia sp.	Asteraceae	Marsh
Tanacetum tibeticum	„	Dry areas
Taraxacum officinale	„	Dry ground
Tanacetum artemesioides	„	Rocky slopes
Crepis sp.	„	Dry ground
Primula sibirica	Primulaceae	Wet mounds
Gentiana tenella	Gentianaceae	Marsh
G. leucomeleana	„	Marsh
Microcala tibetica	Boraginaceae	Edge of steams
Pedicularis longiflora	Scrophulariaceae	Marsh
Veronica lanosa	Scrophulariaceae	Marsh
Utricularia minor	Lentibulariceae	Stagnant Lakes/Pools
Scutellaria heydei	Lamiaceae	Dry ground
Nepeta sp.	„	Dry areas
N. floccosea	„	Dry Ground
Polygonum nummularifolium	Polygonaceae	Marsh
Polygonum sp.	„	Marsh
Equisetum ramossimum	Equisetaceae	Lakes & Ponds

Note: Unidentified plants include five species of sedges (Cyperaceae).

APPENDIX II

List of animals sighted

Birds

			Chushul	Hanle	Chumur	Other Areas	Remarks
1.	Great Crested Grebe	*Podiceps cristatus*	—	—	—	Startsapuk Tso	18 August
2.	Large Cormorant	*Phalacrocorax carbo*	—	—	—	Pangong Tso	September onwards
3.	Grey Heron	*Ardea cinerea*	R	—	—	Fukche, Pangong Tso	Breeding
4.	Barheaded Goose	*Anser indicus*	R	R	—	—	Breeding
5.	Brahminy Duck	*Tadorna ferruginea*	VC	C	VC	Lakes & rivers	Breeding
6.	Common Teal	*Anas crecca*	R	—	—	—	October
7.	Wigeon	*Anas penelope*	R	—	—	—	October
8.	Garganey Teal	*Anas querquedula*	C	C	C	—	August onwards
9.	Shoveller	*Anas clypeata*	R	—	—	—	September onwards
10.	Common Merganser	*Mergus merganser*	—	—	C	Pangong Tso	Breeding
11.	Buzzard	*Buteo* sp.	R	—	R	—	
12.	Blackwinged Kite	*Elanus caeruleus*	R	—	—	—	
13.	Blackeared Kite	*Milvus migrans lineatus*	—	R	—	—	
14.	Hawk	*Accipiter* sp.	—	—	R	—	
15.	Golden Eagle	*Aquila chrysaetos*	—	—	R	—	
16.	Bearded Vulture	*Gypaetus barbatus*	R	R	R	—	
17.	Marsh Harrier	*Cirus aeruginosus*	C	C	C	—	25 August onwards
18.	Osprey	*Pandion haliaetus*	R	—	R	—	
19.	Kestrel	*Falco tinnunculus*	R	C	R	—	
20.	Tibetan Partridge	*Perdix hodgsoniae*	—	—	—	near Hanle and Chushul	Breeding
21.	Blacknecked Crane	*Grus nigricollis*	R	VR	—	—	Breeding
22.	Coot	*Fulica atra*	R	—	R	—	September
23.	Golden Plover	*Pluvialis dominica*	VR	VR	—	—	September
24.	Lesser Sand Plover	*Charadrius mongolus*	C	—	—	—	Breeding
25.	Whimbrel	*Numenius phaeopus*	—	—	—	Startsapuk Tso	
26.	Common Redshank	*Tringa totanus*	C	C	—	Pangong Tso	Breeding
27.	Terek Sandpiper	*Tringa terek*	—	—	—	Pangong Tso	mid-August
28.	Common Sandpiper	*Tringa hypoleucos*	C	—	C	—	Breeding
29.	Snipe	*Gallinago* sp.	R	R	—	—	
30.	Blackwinged Stilt	*Himantopus himantopus*	VR	—	—	—	27 August onwards
31.	Lesser Blackbacked Gull	*Larus fuscus*	VR	—	—	Pangong Tso Indus River	
32.	Brownheaded Gull	*Larus brunnicephalus*	C	—	—	Lakes & rivers	Breeding
33.	Blackheaded Gull	*Larus ridibundus*	R	—	—	Lakes & rivers	
34.	Common Tern	*Sterna hirundo*	C	—	—	Lakes & rivers	Breeding
35.	Tibetan Sandgrouse	*Syrrhaptes tibetanus*	R	C	C	—	Breeding

APPENDIX II

LIST OF ANIMALS SIGHTED

BIRDS

			Chushul	Hanle	Chumur	Other Areas	Remarks
1.	Great Crested Grebe	*Podiceps cristatus*	—	—	—	Startsapuk Tso	18 August
2.	Large Cormorant	*Phalacrocorax carbo*	—	—	—	Pangong Tso	September onwards
3.	Grey Heron	*Ardea cinerea*	R	—	—	Fukche, Pangong Tso	Breeding
4.	Barheaded Goose	*Anser indicus*	R	R	—	—	Breeding
5.	Brahminy Duck	*Tadorna ferruginea*	VC	C	VC	Lakes & rivers	Breeding
6.	Common Teal	*Anas crecca*	R	—	—	—	October
7.	Wigeon	*Anas penelope*	R	—	—	—	October
8.	Garganey Teal	*Anas querquedula*	C	C	C	—	August onwards
9.	Shoveller	*Anas clypeata*	R	—	—	—	September onwards
10.	Common Merganser	*Mergus merganser*	—	—	C	Pangong Tso	Breeding
11.	Buzzard	*Buteo* sp.	R	—	R	—	
12.	Blackwinged Kite	*Elanus caeruleus*	R	—	—	—	
13.	Blackeared Kite	*Milvus migrans lineatus*	—	R	—	—	
14.	Hawk	*Accipiter* sp.	—	—	R	—	
15.	Golden Eagle	*Aquila chrysaetos*	—	—	R	—	
16.	Bearded Vulture	*Gypaetus barbatus*	R	R	R	—	
17.	Marsh Harrier	*Circus aeruginosus*	C	C	C	—	25 August onwards
18.	Osprey	*Pandion haliaetus*	R	—	R	—	
19.	Kestrel	*Falco tinnunculus*	R	C	R	—	
20.	Tibetan Partridge	*Perdix hodgsoniae*	—	—	—	near Hanle and Chushul	Breeding
21.	Blacknecked Crane	*Grus nigricollis*	R	VR	—	—	Breeding
22.	Coot	*Fulica atra*	R	—	R	—	September
23.	Golden Plover	*Pluvialis dominica*	VR	VR	—	—	September
24.	Lesser Sand Plover	*Charadrius mongolus*	C	—	—	—	Breeding
25.	Whimbrel	*Numenius phaeopus*	—	—	—	Startsapuk Tso	
26.	Common Redshank	*Tringa totanus*	C	C	—	Pangong Tso	Breeding
27.	Terek Sandpiper	*Tringa terek*	—	—	—	Pangong Tso	mid-August
28.	Common Sandpiper	*Tringa hypoleucos*	C	—	C	—	Breeding
29.	Snipe	*Gallinago* sp.	R	R	—	—	
30.	Blackwinged Stilt	*Himantopus himantopus*	VR	—	—	—	27 August onwards
31.	Lesser Blackbacked Gull	*Larus fuscus*	VR	—	—	Pangong Tso Indus River	
32.	Brownheaded Gull	*Larus brunnicephalus*	C	—	—	Lakes & rivers	Breeding
33.	Blackheaded Gull	*Larus ridibundus*	R	—	—	Lakes & rivers	
34.	Common Tern	*Sterna hirundo*	C	—	—	Lakes & rivers	Breeding
35.	Tibetan Sandgrouse	*Syrrhaptes tibetanus*	R	C	C	—	Breeding

APPENDIX II (contd.)

			Chushul	Hanle	Chumur	Other Areas	Remarks
36.	Hill Pigeon	*Columba rupestris*	C	C	C	—	
37.	Rufous Turtle Dove	*Streptopelia orientalis*	R	R	—	—	
38.	The Cuckoo	*Cuculus canorus*	VR	—	—	—	8-13 August
39.	Tibet Owlet	*Athene noctua*	—	—	R	—	
40.	Shorteared Owl	*Asio flammeus*	—	VR	—	—	22 September
41.	The Swift	*Apus apus*	C	C	—	—	
42.	Hoopoe	*Upupa epops*	C	R	C	—	
43.	Wryneck	*Jynx torquilla*	VR	—	—	—	
44.	Short-toed Lark	*Calandrella acutirostris*	VC	VC	C	—	Breeding
45.	Longbilled Calandra Lark	*Melanocorypha maxima*	C	VC	—	—	Breeding
46.	Horned Lark	*Eremophila alpestris*	VC	C	—	—	Breeding
47.	Crag Martin	*Hirundo rupestris*	—	C	—	—	Breeding
48.	Common Swallow	*Hirundo rustica*	C	C	—	—	
49.	Brahminy Myna	*Sturnus pagodarum*	R	—	—	—	
50.	Alpine Chough	*Pyrrhocorax graculus*	VC	VC	VC	Pangong Tso	Breeding
51.	Redbilled Chough	*Pyrrhocorax pyrrhocorax*	C	C	C	—	Breeding
52.	Raven	*Corvus corax*	C	C	C	—	Breeding
53.	Lesser Whitethroat	*Sylvia curruca*	R	—	R	—	
54.	Chiffchaff	*Phylloscopus collybita*	R	—	—	—	
55.	Plain Leaf Warbler	*Phylloscopus neglectus*	R	—	—	—	
56.	Olivaceous Leaf Warbler	*Phylloscopus griseolus*	R	—	—	—	
57.	Bluethroat	*Erithacus svecicus*	—	R	R	—	
58.	Tibetan Rubythroat	*Erithacus pectoralis*	R	—	—	—	Breeding
59.	Black Redstart	*Phoenicurus ochruros*	C	C	—	—	
60.	Desert Wheatear	*Oenanthe deserti*	VC	VC	—	—	Breeding
61.	Whitecapped Redstart	*Chaimarrornis leucocephalus*	R	—	—	—	
62.	Robin Accentor	*Prunella rubeculoides*	VC	—	C	—	Breeding
63.	Vinaceousbreasted Pipit	*Anthus roseatus*	—	—	—	Pongong Tso	
64.	Yellowheaded Wagtail	*Motacilla citreola*	VC	VC	—	—	Breeding
65.	Grey Wagtail	*Motacilla caspica*	VC	VC	VC	—	Breeding
66.	Pied or White Wagtail	*Motacilla alba*	VC	VC	VC	—	Breeding
67.	Kashmir House Sparrow	*Passer domesticus parkini*	VC	—	—	—	Breeding
68.	Tibet Snow Finch	*Montifringilla adamsi*	VC	C	VC	—	Breeding
69.	Brambling	*Fringilla montifringilla*	—	VR	—	—	September
70.	Hodgson's Mountain Finch	*Leucosticte nemoricola altaica*	C	VC	C	—	Breeding
71.	Himalayan Mountain Finch	*Leucosticte brandti haematopygia*	C	—	C	—	Breeding
72.	Eastern Great Rosefinch	*Carpodacus rubicilloides*	C	—	C	—	Breeding

Relative abundance: VC = Very Common, C = Common, R = Rare, VR = Very Rare.

APPENDIX II (contd.)

			Chushul	Hanle	Chumur	Other Areas	Remarks
36.	Hill Pigeon	*Columba rupestris*	C	C	C	—	
37.	Rufous Turtle Dove	*Streptopelia orientalis*	R	R	—	—	
38.	The Cuckoo	*Cuculus canorus*	VR	—	—	—	8-13 August
39.	Tibet Owlet	*Athene noctua*	—	—	R	—	
40.	Shorteared Owl	*Asio flammeus*	—	VR	—	—	22 September
41.	The Swift	*Apus apus*	C	C	—	—	
42.	Hoopoe	*Upupa epops*	C	R	C	—	
43.	Wryneck	*Jynx torquilla*	VR	—	—	—	
44.	Short-toed Lark	*Calandrella acutirostris*	VC	VC	C	—	Breeding
45.	Longbilled Calandra Lark	*Melanocorypha maxima*	C	VC	—	—	Breeding
46.	Horned Lark	*Eremophila alpestris*	VC	C	—	—	Breeding
47.	Crag Martin	*Hirundo rupestris*	—	C	—	—	Breeding
48.	Common Swallow	*Hirundo rustica*	C	C	—	—	
49.	Brahminy Myna	*Sturnus pagodarum*	R	—	—	—	
50.	Alpine Chough	*Pyrrhocorax graculus*	VC	VC	VC	Pangong Tso	Breeding
51.	Redbilled Chough	*Pyrrhocorax pyrrhocorax*	C	C	C	—	Breeding
52.	Raven	*Corvus corax*	C	C	C	—	Breeding
53.	Lesser Whitethroat	*Sylvia curruca*	R	—	R	—	
54.	Chiffchaff	*Phylloscopus collybita*	R	—	—	—	
55.	Plain Leaf Warbler	*Phylloscopus neglectus*	R	—	—	—	
56.	Olivaceous Leaf Warbler	*Phylloscopus griseolus*	R	—	—	—	
57.	Bluethroat	*Erithacus svecicus*	—	R	R	—	
58.	Tibetan Rubythroat	*Erithacus pectoralis*	R	—	—	—	Breeding
59.	Black Redstart	*Phoenicurus ochruros*	C	C	—	—	
60.	Desert Wheatear	*Oenanthe deserti*	VC	VC	—	—	Breeding
61.	Whitecapped Redstart	*Chaimarrornis leucocephalus*	R	—	—	—	
62.	Robin Accentor	*Prunella rubeculoides*	VC	—	C	—	Breeding
63.	Vinaceousbreasted Pipit	*Anthus roseatus*	—	—	—	Pongong Tso	
64.	Yellowheaded Wagtail	*Motacilla citreola*	VC	VC	—	—	Breeding
65.	Grey Wagtail	*Motacilla caspica*	VC	VC	VC	—	Breeding
66.	Pied or White Wagtail	*Motacilla alba*	VC	VC	VC	—	Breeding
67.	Kashmir House Sparrow	*Passer domesticus parkini*	VC	—	—	—	Breeding
68.	Tibet Snow Finch	*Montifringilla adamsi*	VC	C	VC	—	Breeding
69.	Brambling	*Fringilla montifringilla*	—	VR	—	—	September
70.	Hodgson's Mountain Finch	*Leucosticte nemoricola altaica*	C	VC	C	—	Breeding
71.	Himalayan Mountain Finch	*Leucosticte brandti haematopygia*	C	—	C	—	Breeding
72.	Eastern Great Rosefinch	*Carpodacus rubicilloides*	C	—	C	—	Breeding

Relative abundance: VC = Very Common, C = Common, R = Rare, VR = Very Rare.

APPENDIX II (contd.)

FISHES	
1. *Schizopygopis stoliczkae*	
2. *Ptychobarbus conirostris*	
3. *Noemacheilus* sp.	
REPTILE	
Toad-Agama	*Phrynocephalus theobaldi*
MAMMALS	
1. Wolf	*Canis lupus*
2. Red Fox	*Vulpes vulpes*
3. The Himalayan Marmot	*Marmota bobak himalayana*
4. Quetta Vole	*Ellobius fuscocapillus*
5. Woolly Hare	*Lepus oiostolus*
6. Himalayan Mouse-Hare	*Ochotona roylei*
7. Tibetan Wild Ass	*Equus hemionus kiang*

MISCELLANEOUS NOTES

1. PAINTED BATS AND NESTS OF BAYA WEAVER BIRD

During July-August 1984 while I was studying some colonies of Baya Weaver Bird (*Ploceus philippinus*) at Kishore Pura Mixed Plantation Area in Alwar District, Rajasthan. I found three different half built nests of the baya, *P. philippinus* on different trees of *Prosopis spicigera* which were occupied by painted Bat *Kerivoula picta*. My observations are as follows (Table 1).

TABLE 1

Sl. No.	Date of observation	Area Surveyed	Stage of nest occupied by bats	Time of observation	Host plant on which baya colony was present	No. of bats observed in the nest
1	15th July 1984	25 ha.	Half built	1400 hrs.	*Prosopis spicigera*	1
2	1st August 1984	25 ha.	Half built	1500 hrs.	*P. spicigera*	4
3	4th August 1984	25 ha.	Half built	1000 hrs.	*P. spicigera*	1

Along with half built nests, I have examined a large number of completed nests also but these held no bat. I have observed a fair number of half built and completed nests of *P. benghalensis* also but all were without bats.

The Bats use the ceiling of the nest for hanging instead of the chinstrip of the nest. I never saw any male baya on such encroached nests.

The observed area is an undulating, hilly area with sparse vegetation. *Prosopis spicigera, Saccharum munja, Leptadinia sparitum, Lizyphus* spp., *Calotropis procera* etc. are important species growing here. Most of *Prosopis spicigera* trees are rather stunted due to repeated illicit felling and lopping. A lot of old trees have been hacked down for firewood and fodder, with the result that several hole nesting and roosting birds, mammals and other animals have no suitable site for making nests or roosts. Bats are probably using these baya nests as roosting place owing to scarcity of roosting sites.

SATISH KUMAR SHARMA

FOREST RANGE OFFICER,
UDAIPUR (WEST) RANGE,
GULAB BAGH ZOO,
UDAIPUR-313 001,
RAJASTHAN,
February 13, 1986.

2. A NOTE ON THE RHESUS MACAQUE (*MACACA MULATTA*) FEEDING ON CALOTES

While walking through the woodlands of Bharatpur, Keoladeo National Park, I saw near the Bison mori area a troop of Rhesus monkeys feeding on the ground vegetation. An adult female was sitting near a termite mound. She suddenly captured a calotes lizard and carried it to an Acacia mound nearby. Holding the lizard by its upper part, she bit off its head with lightning speed and devoured it immediately. Next she ate the tail, followed by the thighs. She then opened its belly, threw away some of the intestinal parts and ate the rest. She then sat down more comfortably, peeled off the skin let it drop and ate practically the entire remaining portion.

According to Roonwal and Mohnot (1977) '*M. mulatta* is largely vegetarian, its diet including leaves, flowers, fruits, berries, seeds of many species of plants, grass, grains, and algae from ponds. It is not known to eat small birds, lizards or similar small animals'. Prater (1971) states that 'Ground plants, insects and spiders are their usual fare'.

ACKNOWLEDGEMENTS

I thank Dr. V. S. Vijayan, Project Scientist and Dr. (Mrs.) Lalitha Vijayan, Senior Field Biologist, BNHS Ecological Research Centre, Bharatpur, for their encouragement.

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331, RAJENDRA NAGAR,
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RAJASTHAN, INDIA,
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3. A PANTHER'S MISADVENTURE

On 13-8-82 tribals noticed unusual agitation among common langurs, between the footpath from Loghouse at Theppakkadu to the first watch tower. The focus of their attention was the carcass of a panther hanging on a Teak tree, neck held in a fork of a branch at a height of about 25 m. The carcass which was well hidden in the canopy was dry and the fur was falling off in flakes and floating in the air. The langurs were coughing at the fallen and floating fur pieces and at the carcass. The carcass appeared to be 20-25 days old. No one had noticed it though the footpath was almost directly underneath and was being used frequently.

We could only guess at the cause: It is

possible that the Panther attempted to chase or catch a langur missed a hold or slipped, and the head got irretrievably caught in the fork. Was death instantaneous from the momentum of the moving body causing the break in the neck when the head was caught in the fork?

J. MANGALRAJ JOHNSON

WILDLIFE WARDEN,
MUDUMALAI SANCTUARY,
TEMPLETON COTTAGE,
UDHAGAMANDALAM,
TAMIL NADU,
June 28, 1986.

4. IMPRINTING IN SPOTBILL DUCK *ANAS POECILORHYNCHA*

It is well known that the eggs of wild birds can be successfully hatched in incubators or under domestic hens. Artificially reared chicks of wild geese and ducks, during their early life, recognise any large moving object as their mother and start following it. The foster birds which rear them or even human beings are also followed by such chicks. This following response, technically known as imprinting, was first described by Heinroth (1910). This communication reports on imprinting in a Spotbill Duck *Anas poecilorhyncha* reared under a domestic hen at Harike (Punjab). Though imprinting has been well established in Mallard *Anas platyrhynchos*, Tufted Duck *Aythya fuligula*, Moorhen *Gallinula chloropus*, Coot *Fulica atra*, Wood Duck *Aix sponsa* and Shelduck *Tadorna tadorna* (Hinde *et al.* 1956, Hess 1957, Thorpe 1964, Van Tyne and Berger 1976), it had not been reported in Spotbill Duck so far.

We came to know about the Spotbill Duck on 5 February 1985 when one of us (MSD) visited the Harike Bird Sanctuary along with Dr. Robert Grubh and Mr. S. A. Hussain of the Bombay Natural History Society. The Spotbill was feeding in shallow water just at the bank of the lake along with a domestic duck. Mr. Sucha Singh, Boatman of the Punjab State Fisheries Department, who had hatched the duck under a domestic hen, could not be contacted that day. On 27 March, we again visited Harike and interviewed Sucha Singh. Following is the summary of what he told us about the duck.

A nest of the Spotbill was found in a bunch of *Phragmites* in the littoral zone of the lake during April 1984. There were six eggs in the nest which seemed to be deserted. Fearing that the eggs will be devoured by some predator, Sucha Singh collected them and put them under an incubating domestic hen. Only three eggs hatched in about 25 days. He fed the Spotbill chicks on moistened wheat flour plus wheat bran and provided water ad libitum. The chicks followed the foster hen who looked after them just like other chicks. Two chicks fell to some predator at the age of one month whereafter he took special care of the third chick so that it may survive. Every day in the morning, he would make an enclosure with a fish net in shallow water just near the margin of the lake and release the chick in it for feeding. He would take out the chick in the evening. The chick then started following him to his house where it was offered additional food and put in a cage for night. This chick, a female, has survived.

The Spotbill is now one year old. She leaves home daily and flies to the distant parts of the lake to feed in the company of wild birds but regularly returns home. Sometimes she does not go far away and feeds in shallow water near the bank of the lake along with a female domestic duck which was also reared under the same hen. Whenever the Spotbill starts going away from the lake shore, the domestic duck makes a lot of noise as if calling her back. She often leaves water and comes to Sucha Singh's house during the daytime where she is offered *chapati* pieces. Whenever he called *aa....aa....aa....aa*, she obliges and comes out of water to feed on whatever is offered by him. Curiously, since the last two weeks, a wild male Spotbill accompanies her from the lake up to the shore as if to say "good bye" to her. Sometimes while following her, he even comes out of water but remains at a distance. Probably she has mated with this male but whether they have made a nest is not known.

Having lived in association with Sucha Singh for about a year, the Spotbill seems to have no fear of man. We photographed her from as close as 3 m and she was not at all disturbed. This case seems to be the extreme case of imprinting in which, according to Thorpe (1964), the young bird comes to accept a "human being as its proper associate and to retain for the rest of its like a tendency to regard human beings as fellow members of its species".

DEPT. OF FORESTRY & NATURAL
RESOURCES,

MANJIT S. DHINDSA

DEPT. OF ZOOLOGY,
PUNJAB AGRICULTURAL UNIVERSITY,
LUDHIANA-141 004, PUNJAB,
April 30, 1985.

JASWINDER S. SANDHU

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5. DUCK MIGRATION ACROSS THE HIMALAYA — TUFTED DUCK *AYTHYA FULIGULA* AT 13,700′ ON ROHTANG PASS, HIMACHAL PRADESH

On 15th June 1985, I set off from the 13,000 ft. Rohtang Pass diagonally traversing the 15,000 ft. Rohtang Pyramid on the west flank of the pass to visit Dashawe Kund a high altitude lake at over 14,500 ft. on the main Pir Panjal range across which the Rohtang Pass gives passage to Lahoul.

About 700 ft. above the pass I came across a dead drake of the Tufted Duck *Aythya fuligula.* The bird was in good state of preservation and had apparently died a few days earlier, though small red ants had attacked the eyes. The bird had an injury on its left side suggesting that it had struck the mountain while speeding north across the pass, presumably in bad weather when clouds make for poor visibility well below the pass itself. Even if the crossing is attempted on a clear day, strong winds blow down the pass forcing birds to fly low against the head wind and an accident might easily be caused.

Several years ago I had reported the recovery of a Common Teal exhausted on the Beas Kund Glacier not far from where the Tufted Duck was located.

14 Jayant Society,
Rajkot 360 004,
Gujarat,
June 27, 1985.

LAVKUMAR KHACHER

6. COMMUNAL GATHERING OF BLACKWINGED KITES (*ELANUS CAERULEUS VOCIFERUS*)

On 6.5.84 in the Ranthambhor Tiger Reserve Shri Fateh Singh, the Field Director, two friends and I set off from Jogi Mahal at about 3.40 p.m. to locate and photograph tigers. Opposite the second lake we approached a Dhok tree, *Anogeissus pendula,* on the side of the road in the vicinity of which a pair of Blackwinged kites were observed for the past few weeks and on many occasions also perched on the tree. As we passed the tree three Blackwinged kites flew from it immediately followed by many more. We stopped and eventually counted positively twelve, and there were altogether probably about fifteen to seventeen birds flying out of this single tree. They then flew around, some settling on nearby trees. As the evening's purpose was to locate tigers we unfortunately had to proceed and thus no further observations were possible. The park is well represented with Blackwinged kites but gatherings of so many together have never before been recorded so early during the day. Past records indicate that they are known to roost communally at dusk. No signs of breeding were evident though the breeding season of this species is in April & May. It is extended (according to Ali 1954, Ali & Ripley 1968) varying locally to cover practically the entire year. No other evidence of easy availability of any concentrated food source was observed, to account for this unusual gathering behaviour. One can only speculate the reason and put it down for the record.

ACKNOWLEDGEMENTS

I am indebted to Shri Fateh Singh Rathore for taking me around and whose help and support was invaluable during my search for and photographic sessions on the Bonelli's eagle. Thanks also to Valmik Thapar and Tejbir Singh for helping out in so many ways.

RISHAD NAOROJI

Belha Court,
24, Strand Road,
Bombay-400 039,
July 29, 1985.

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7. THE PARIAH KITE *MILVUS MIGRANS* (BODDAERT) FEEDING ON FLOWERS!

On 26th March I was with the Sarabhai family having a picnic lunch on the lawn of their Usmanpura house across the Sabarmati River to Ahmedabad city. There was a brisk breeze blowing in from the north-east providing ideal conditions for Pariah Kites to indulge in their mastery of aerobatics. Admiring their flight abilities we noticed individuals feeding on some light coloured objects. Sometimes a piece would fall and another kite would come swooping in to catch the piece in mid air. Some of us presumed they were playing, others thought it was the passing of food between a bonded pair and ofcourse a third opinion was that we were seeing parents teaching their fully fledged young the art of catching objects in mid air!

Observing the kites more carefully I noticed that they came in against the wind to snatch a flower from a tall *Tubobea* tree. The flower would be eaten in the usual kite fashion in flight and pieces accidentally being dropped in the process would be swooped on by other kites. Once a flower flew off from the tree in a particularly strong gust of wind and a kite immediately swooped down and caught it in its extended talons. There were more than half a dozen kites circling overhead eating the flowers!

LAVKUMAR KHACHER

14, JAYANT SOCIETY,
RAJKOT 360 004,
April 2, 1986.

8. PECULIAR FEEDING BEHAVIOUR OF THE SHIKRA *ACCIPITER BADIUS* (GMELIN) & THE HONEY BUZZARD *PERNIS PTILORHYNCUS* (TEMMINCK)

On July 17, this year, I saw a Shikra along with a Crow-Pheasant moving about on the ground and constantly picking up something with its bill. This was in my garden here in Bhuj. On going closer to investigate as to what it was eating, I found that the two birds were feeding on flying termites as they emerged from underground. Elsewhere in my garden the termites which were coming out and flying up were being caught on the wing by crows, drongos etc. However the shikra concerned, never even once made an effort to catch a flying insect. While in the process of eating it was twice disturbed by passers-by when it flew up and sat on the branch of a neem tree nearby to come down again to resume its peculiar way of feeding. It remained on the ground for at least about 15 minutes, walking with an awkward gait and picking up the winged termites.

I have also observed more than once a Crested Honey Buzzard coming down on an open plot in my garden to eat white ants. This buzzard did not move about, but kept sitting near the termites' nest hole and continued eating the insects after exposing them by removing the sand covering with sideways movements of its beak.

This mode of feeding by these two birds of prey has not been mentioned in any of the reference work I have with me, and hence this note to elicit information whether this has been ever observed by any one else.

JUBILEE GROUND,
BHUJ, KUTCH,
July 30, 1985.

HIMMATSINHJI

[Though the Shikra is known to take flying insects on the wing by dashing after them, Hume and Davison record them frequently descending to the ground to pick up something (*Stray Feathers 6*: 7-8). As regards Honey Buzzard, Major R. S. P. Bates records one of the pair hanging about his bungalow in Chittagong busily devouring termites on the ground. Whenever winged swarms appeared along with the Pariah and Brahminy kites, mynas and crows, the Honey Buzzards were seen wheeling to and fro screaming continuously (*J. Bombay nat. Hist. Soc. 38*: 162) — Eds.]

9. A CRESTED HAWK-EAGLE *SPIZAETUS CIRRHATUS* (GMELIN) KILLING A PEAFOWL *PAVO CRISTATUS* LINNAEUS

A leopard had hidden its sambar kill in some thick lantana scrub, very close to our observation hut in the Koktu-Valley in the core area of the Melghat Tiger Reserve. In the early hours of 29th May 1986, we were trying to stalk the leopard which seemed reluctant to leave the kill area, possibly owing to the presence of other carnivora. Suddenly, very agitated alarm calls of a peafowl (*Pavo cristatus*) and Grey Junglefowl (*Gallus sonneratii*), of which the undergrowth seemed to be full of, erupted all round us. Sinking to the ground, we saw an adult Crested Hawk-Eagle (*Spizaetus cirrhatus*), go skimming over the lantana. Sighting two peahens, i.e. (*landor*) it swerved with spread wings and attempted to herd them towards the embankment. One of the Peafowl managed to take off but the other skidded around. The eagle fanning its huge wings hopped after her and jumped on her back, wrapping its wings around its prey. They tumbled behind some rocks accompanied by desperate screams of the *landor*. After three or four seconds there was total silence. We waited for 15 minutes, but the birds did not appear. Next day some bits of skin and feathers were found. The Peafowl must have been at least one-third bigger than her attacker.

108, RAMDASPETH,
NAGPUR - 440 010,
July 8, 1986.

AMRUT S. DHANWATEY

10. PREDATION ATTEMPT BY BLACK EAGLE (*ICTINAETUS MALAYENSIS PERNIGER*) ON INDIAN GIANT SQUIRREL (*RATUFA INDICA ELPHINSTONII*)

On the 13th of December 1985, at Bhimashankar (District Pune, Maharashtra. Lat: 19°4′N. Lon: 73°32′E.), I witnessed a predation attempt by a black eagle (*Ictinaetus malayensis perniger*) on an adult male Giant Squirrel (*Ratufa indica elphinstonii*). The incident occurred at 1036 hrs. It was a cold morning and the adult male squirrel, exposed fully to the sun, was feeding on the inner bark of the wild mango (*Mangifera indica*), at the top of the tree. I observed a black eagle that had been gliding over the canopy, suddenly swoop so low over the squirrel that it smacked the vegetation with its wings. The sound on impact was considerable. The squirrel dashed away without sounding an alarm and concealed itself in thick foliage at a lower level. It remained there, motionless and quiet, for nineteen minutes while the eagle continued to glide in the vicinity before moving out of view.

Squirrels generally sound an alarm when a Crested Serpent Eagle (*Spilornis cheela*) or a Black Eagle is overhead. Therefore, avian predation on these squirrels must occur. Though, I have often heard locals in the semi-evergreen forest of Yellapur in the Malnad region of Karnataka, relate incidents of actual predation by the Crested Serpent Eagle (*S. c. melanotis*) on the Giant Squirrel (*R. i. indica*) this is the first time I have observed a predation attempt by a raptor on this squirrel.

RENEE BORGES

BHIMASHANKAR,
TALUKA AMBEGAON,
DISTRICT PUNE,
MAHARASHTRA,
March 6, 1986.

11. A LARGE ROOST OF HARRIERS IN ANDHRA PRADESH, INDIA

Near Rollapadu village, which is 20 km east of Nandikotkur town (15° 52′ N and 78° 18′ E) in Kurnool district, Andhra Pradesh, India, an eight hundred acre grassland plot has been protected (from grazing) from 1984 for the breeding of the Great Indian Bustard. The dominant grass species are *Heteropogon contortus, Chrysopogon fulvus, Eremopogon foveolatus,* and *Aristida funiculata.* The surrounding area is also open, flat or gently undulating grassland, occasionally punctuated by crop fields. Grasshoppers are so abundant that one flushes a few at every step.

In winter, the grasslands of Rollapadu attract large numbers of harriers and short-toed larks. During the winter of 1985-86, our estimate is that between 800 to 1,000 harriers used to roost in the Rollapadu grassland enclosure. During the day, fifty to sixty harriers could be seen tirelessly quartering the grassland and by evening, birds from the surrounding areas would arrive and after sunset, hundreds of harriers could be seen either sitting on the ground or flying just above the ground in search of a roosting place. Due to continuous movement of birds, it was extremely difficult to count them, but our estimate is that about one thousand harriers could be seen. This could be vertified by the number of roosting sites. In one open fallow field of about five acres, we counted 42 rooting spots.

Both, tall grassland and bare open fallow fields/burnt areas were selected for roosting but more birds used to roost in the grassland. In the grassland also, two areas were more frequently used and about fifty per cent of the harriers roosted in these areas. Apparently similar areas were not occupied throughout the winter.

Ninety per cent of the adult male harriers were identified as Montagu's (*Circus pygargus*), while the remaining were Pale (*C. macrourus*) and Marsh (*C. aeruginosus*). Ali & Ripley (1968) opine that the Montagu's Harrier is perhaps slightly less common than the Pale but both are equally widely distributed over the subcontinent. However, in Rollapadu we found that almost all the adult male harriers which could be unmistakably identified were Montagu's. We do not know the species composition of the immature and female harriers because they were difficult to identify in the field.

Bombay Natural History Society,
Hornbill House,
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Bombay-400 023,
May 24, 1986.

ASAD R. RAHMANI
RANJIT MANAKADAN

Reference

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12. PRE-MIGRATORY FLOCKING OF THE DEMOISELLE CRANE, *ANTHROPOIDES VIRGO* (LINNAEUS)

The Demoiselle Crane, *Anthropoides virgo*, is a common winter visitor in the north-western and west-central parts of the Indian subcontinent (Ali and Ripley 1983). The Saurashtra region (lat. 20° 10′ and 24° 45′ N, long. 68° 10′ and 70° 30′E) of Gujarat State is now recognised as an important wintering ground of these cranes.

We frequently visit, the Lalpari Dam reservoir located within the Rajkot city limit and the Nyari Dam reservoir outside the city limit, and watch the cranes usually resting, but sometimes also feeding, on the banks and islands of the reservoirs in the morning and evening. During October to February the usual number of cranes recorded by us ranged from about 300 to 2000 at Lalpari and 700 to 4000 at Nyari (Table 1).

Between 1 and 20 March 1985, we visited the Lalpari reservoir on several evenings and counted about 2000 to 4000 cranes during each visit. However, when we visited the reservoir on the evening of 22 March, we witnessed a spectacular assembly of cranes the

TABLE 1

NUMBER OF DEMOISELLE CRANES RECORDED AT LALPARI AND NYARI RESERVOIRS, RAJKOT

Lalpari reservoir		Nyari reservoir	
Date & time*	No. of cranes	Date & time*	No. of cranes
12.x.83. M	1447	7.x.83. M	771
1.xi.83. M	1242	6.xi.83. M	1823
17.xii.83. M	1483	3.xii.84. M	3054
18.xii.83. M	338	9.xii 84. M	4038
25.xii.83. M	2025	26.xii.83. M	1465
15.i.85. E	500	5.i.84. M	3787
15.xii.85. E	2000	13.i.84. M	1415

* M—morning hours between 0900 to 1100.
E—evening hours between 1700 to 1900.

like of which we had never witnessed before. When we reached the reservoir at about 1800 hrs, a few hundred cranes were feeding in the crop fields near the reservoir. Then, more and more birds started coming in from the surrounding areas to land on the reservoir bank. At first the inflow of birds was slow and we could count the number of incoming birds, but after sunset flocks after flocks of birds from several directions started converging to land on the reservoir banks in rapid succession so that after counting about 20,000 birds, we gave up counting. When we left the site under the rapidly fading light of the dusk, we left behind a huge congregration of cranes standing on a vast expanse of the gradually sloping reservoir banks, and still more cranes coming in.

We visited the Lalpari reservoir again, on the evening of 23 March and witnessed a large number of cranes assembling as on the previous day. However, on 24th evening, only about 3000 cranes assembled there in the evening and on 25th evening none came there. On 22 March evening, some of our friends had gone to Nyari reservoir and had seen there only about 54 cranes. These observations suggest that the cranes from the areas atleast around Rajkot were flocking together and roosting at Lalpari on 22 and 23 March.

The cranes are known to leave Saurashtra for their return journey to their breeding quarters in the second half of March. The date of migration is usually inferred by noting an increased nocturnal flights of cranes over certain areas. Our observations reveal that prior to migration the cranes from a vast area tend to assemble at one particular site for roosting, and this gathering of cranes may occur over a few days before they finally depart. The observation is significant in that by keeping the large assembly formation of cranes under observation, the date of departure from an area can be determined with a relatively high degree of precision.

ACKNOWLEDGEMENT

We are greatful to Prof. R. M. Naik, Department of Biosciences, Saurashtra University, Rajkot for his criticism and help.

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REFERENCE

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13. FEEDING METHOD OF SPOON-BILLED SANDPIPERS ON A MUDFLAT IN SOUTH KOREA

The peculiar spatulate bill of Spoon-billed Sandpipers *Eurynorhynchus pygmaeus* has led to much speculation about the bill's particular function and evolution, which is, however, hampered by the scarcity of detailed accounts of the bird's foraging behaviour (Burton 1971). This note is to add to the existing, but rather anecdotal, information about the foraging behaviour of Spoon-billed Sandpipers.

From 14 to 28 September 1984 the waders of the Nakdong Estuary (35°15′N; 129°10′E) near Pusan in South Korea were studied (Piersma 1985). On 17 September 4 and on 26 September 11 Spoon-billed Sandpipers were counted at high tide. On both occasions, the birds roosted, one by one, over the 4 km long and 100-200 m wide, sandy and bare barrier island Galmaegi Deung, amongst flocks of Red-necked Stints *Calidris ruficollis.* All the Spoon-billed Sandpipers observed were in juvenile or winter plumage.

On 24 September I encountered 5 Spoon-billed Sandpipers during low tide on an intertidal flat (unvegetated soft sandy mud, very uniform), one km north of the roosting places on Galmaegi Deung. The birds foraged individually, in the neighbourhood of Dunlins *Calidris alpina.* When foraging on dry surfaces, the birds walked quickly, straight-on, and pecked sideways, alternately to the left and to the right, with a rate of about one peck per one or two sec. During some of the pecks, birds made short vibrations in the sediment with the tip of the spatula. When arriving in shallow water (1-2 cm, i.e. 'knee-deep'), the foraging method changed abruptly. The birds started to walk much slower and made continuous series of rapid but clearly discernible sideways movements (left to right and *vice versa*) of the spatula through the shallow layer of water, alternated with short series of discrete pecks. During foraging, the bill was held down (almost) vertically. During a protocol of 46 sec. (recorded on a tape-recorder), a bird spent two bouts of 2 and 5 sec. preening. In the remaining 39 sec, 54% of the time (21 sec.), the tip of the bill was submerged, making these rapid sideways swishing movements in 5 different bouts. Between these bouts, series of 7, 6, 10, 2 and 1 discrete pecks were made. The swishing movements reminded me strongly of the sideways sweeps made during foraging by Spoonbills *Platalea leucorodia,* although the tempo was much higher in Spoon-billed Sandpipers. I was unable to observe if the Spoon-billed Sandpipers had their mandibles slightly opened during the swishes, as can easily be seen in Spoonbills. The birds were observed at a distance of 30-50 m with a 20X-60X zoom-telescope, but I was unable to see any food items being ingested by the birds. I therefore suggest that the Spoon-billed Sandpipers took very small macrobenthic animals (retained by a 1 mm sieve), or even smaller, meiobenthic prey. The sampling work of Y. W. Jo (Institute of

Marine Sciences, Pusan; pers. comm.) performed at a nearby site one month before my observations, suggests that the prey may consist of small polychaete worms (notably *Prionospio krusadensis* and *Notomastus latiraceus,* the only two abundant worms here) and small crustaceans (*Corophium* and Haustoriidae species). No small bivalves or small gastropods were found on this locality.

On their north-east Siberian arctic tundra breeding grounds, Spoon-billed Sandpipers ate many kinds of insects (adults and larvae), which were captured in the air and on the ground by discrete pecking movements (Portenko 1957). Dixon (1918) saw birds foraging along a shoreline, taking insects and their larvae from piles of algae washed together. Jahn (1942) mentions a bird in Japan that made continuous sieving movements with its bill through soft mud, in half circles around itself and entering the water up to its belly. Voronov (1980) observed a Spoon-billed Sandpiper on a beach at Sakhalin Island, racing up and down the shore following the breaking waves (probably much like Sanderlings *Calidris alba*). The bird took small crabs which were washed out of the sediment by the turbulent water, occurring in densities of 10 000's per m^2. At Hong Kong and at Point Calimere, Tamil Nadu, India, Melville (1978 and pers. comm.) observed that foraging Spoon-billed Sandpipers often made side to side movements with their bill through the upper layer of the sediment (resp. damp mud and wet sand). Portenko (1981) mentioned an observation by V. E. Yakobi of Spoon-billed Sandpipers foraging on an estuary-bank at low tide: 'Running a little in the shallow water, they would rapidly extract food consisting of tiny larvae from the semifluid silt' and, compared to nearby foraging eastern little(?) stints, Spoon-billed Sandpipers 'submerged the beak in the water somewhat more deeply and flicked it from right to left'. Swennen & Marteijn (MS) made detailed observations at an intertidal flat in Thailand and reported that Spoon-billed Sandpipers made drilling (up and down) movements with their bill, usually in front of the body but also to the sides. The bill never went deeper down in the mud than the spatula.

This short review suggests that Spoon-billed Sandpipers are able to use their spatulate bill in a variety of ways. However, with the possible exception of Portenko (1981), no author has mentioned the Spoonbill-like sideways swishes of the spatula through a layer of water on top of soft sediments, as was observed in Nakdong Estuary.

ACKNOWLEDGEMENTS

I am grateful to NEDECO (Netherlands Engineering Consultants) for financing this study, to Marjolein Veldkamp for translating a Russian note into Dutch, to Jan Hulscher and David Melville for comments and to many other people, mentioned in the report, for other kinds of help.

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14. STRANGE DIVERSION ENACTED BY A NIGHTJAR

On the 7th of May '85 at 5 p.m. I was following a fresh trail to photograph a small herd of Gaur at the Radhanagari Bison Sanctuary at Dajipur in the Sahyadris. While hurriedly crossing a small clearing in the dense forest a nightjar took off from a shrub nearby.

The bird promptly put up a convincing broken wing display. In fact it performed so well that my friends were sure it was dying and wanted to help! I took a hurried picture since we were more interested in following the disappearing Gaur.

When we came back to the same area half an hour later the bird repeated the same behaviour. After I had followed it around for a few minutes to get a picture, we left it alone and began to carefully search for the nest. The bird seemed to instantly realize that the trick was a failure and we had seen through it.

It then changed to a surprisingly different strategy. Flying some distance away on perfectly healthy wings it settled down near a bush on the ground, gently shuffling her wings and breast feathers, as ground nesters do when adjusting themselves on their nests.

I was so sure that we had located the nest that I erept slowly towards the now quietly settled nightjar, camera on the ready. As I approached however it flew off and I went closer to photograph the nest with the expected eggs or chicks in it.

To my utter surprise there was nothing there but bare lateritic rock.

The bird had enacted the whole episode, pretending that it had settled on the nest, while actually her eggs or chicks were surely hidden safely elsewhere.

I had never heard of a bird pretending to incubate on a non-existant nest so as to divert attention from the site of the real nest to that of fictitious one.

Recently I again saw a similar display by a Pratincole though it appeared to be part of the regular broken wing display. The HANDBOOK OF THE BIRDS OF INDIA AND PAKISTAN. Vol. 3 (1969), p. 17 also describes a similar pattern incorporated into the display.

I would like comments from any other observers of a similar episode seen in any species, wherein a bird has convincingly pretended to incubate at a 'pseudo nest'.

'Saken', Valantina Society,
North Main Road,
Koregaon Park,
Pune 411 001,
April 12, 1986.

E. K. BHARUCHA

15. MASS COURTSHIP DISPLAY BY GREAT PIED HORNBILL, *BUCEROS BICORNIS*

On the evening of 24th April 1985, while staying at the Forest Rest House, near Tipi Orchid Research Station, Arunachal Pradesh, during the course of a survey on Butterflies as a UN/FAO/UNDP Consultant, my companion Dr. Pratap Singh, of the Forestry Research Institute, Dehra Dun, drew my attention to the fact he had just seen no fewer than eight hornbills fly across the river.

I immediately got my Nikon 10×25 Binoculars and quickly located them all in one tree some 100 metres across the Bhalukpong river. As we watched it seemed that some unusual activity was taking place. There were at that time 4 distinct pairs of birds standing on the branches facing each other and with some deliberation knocking their beaks together and then rubbing them up and down. While scanning a few trees further downstream, I was excited to see more hornbills engaged in the same antics.

Dr. Singh and I were frantically taking turns with the binoculars to see this extraordinary display and counting the number of birds involved and each time the number seemed to increase. When the count finally reached 16 (at this time all in the same tree-which was shaking visibly) we thought we had witness something quite unusual, however, the best was yet to come!

We had noticed, briefly, that ever so often a bird would appear to literally jump or fall out of the tree, seemingly out of control, but each time recovering some distance from the ground and return to its original perch. Keeping a very close watch on two males, visible at the same time, we noticed one hop a short way up a branch and tug with some vigour at the bulb of some tree orchids (with yellow flowers, that were everywhere). After a violent tussle the bird, to our amazement, stepped off the branch almost doing a somersault in the process but still retaining a firm grip on the orchid bulb. It hung there like a trapeze artiste for a few seconds and then by holding its wings half open (like a cormorant) and flapping vigorously it started to twist back and forth and jerk at the same time.

With the entire weight of the bird tugging, of course he got the bulb dislodged and most undignifiedly disappeared in reverse towards the ground with wings flapping madly and successfully pulled out before the reaching the ground into orderly flight and return to the patient waiting lady friend who was duly presented with the hard won trophy. She held it in her beak, but as far as I know didn't eat it. We watched several other males going through the same performance. By this time it was getting fairly late as we had been watching them for a good hour. Suddenly, as if on a given signal, they flew out of the tree, one by one, back to our side of the river. Like a countdown we checked the numbers and came up with 21 birds — what the odd one out thought about all these "spring in the air" goings on we will never know!

In all my years of bird watching it was quite one of the most remarkable displays I have ever seen. Dr Pratap Singh, who knows a lot more about Indian birds than I do, reckoned it had to be some kind of record so we share it with other members of the BNHS — perhaps someone else has seen a similar display?

Only having a 100 mm lens I took a few photos, but it was hopeless and needed a 600 mm lens at least. Also I only had 50ASA film as 200 ASA was unavailable.

ANGUS F. HUTTON

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16. DE-TICKING BY A LARGE GREY SHRIKE, *LANIUS EXCUBITOR*

(*With a plate*)

According to the HANDBOOK (Ali & Ripley 1983), the large grey shrike (*Lanius excubitor*) is a wary bird usually difficult to approach. Its food is recorded as insects, lizards, rodents, young and sickly birds.

During a recent great Indian bustard (*Ardeotis nigriceps*) survey of Rajasthan, we found that the large grey shrike was fairly common around human habitation and could be approached to within five metres.

In Jaisalmer district, on 25th January 1986 at the Desert National Park chowki of Sam, we had a most interesting observation of the shrike's feeding habits. At about 0800 hours, a large grey shrike was seen to de-tick a sitting camel (Plate 1). At our approach it flew off with a tick in its beak and consumed it on the roof of a nearby hut before returning to further investigate the camel's body. When a common myna (*Acridotheres tristis*) hopped close to the camel, the shrike threatened it by fanning its tail, slightly parting its wings and ruffling its neck feathers.

A few days later at the Miyajlar chowki a shrike was seen perched on a branch just above a camel. Still later at the Khuri area of the Desert National Park, while scanning for bustards from camel back, a shrike alighted on a bush within 1.5 m of the camel. It followed the camel for a short distance before flying off. While in the latter two instances de-ticking was not observed they indicated an interest of the shrike in camels.

It seems that the large grey shrike has learnt to de-tick camels in the desert areas probably due to the scarcity of normal insects (especially during winter when insects population is very low). As this behaviour has not been recorded in other areas by us, it is obviously a case of an acquired habit.

RAVI SANKARAN
ASAD R. RAHMANI

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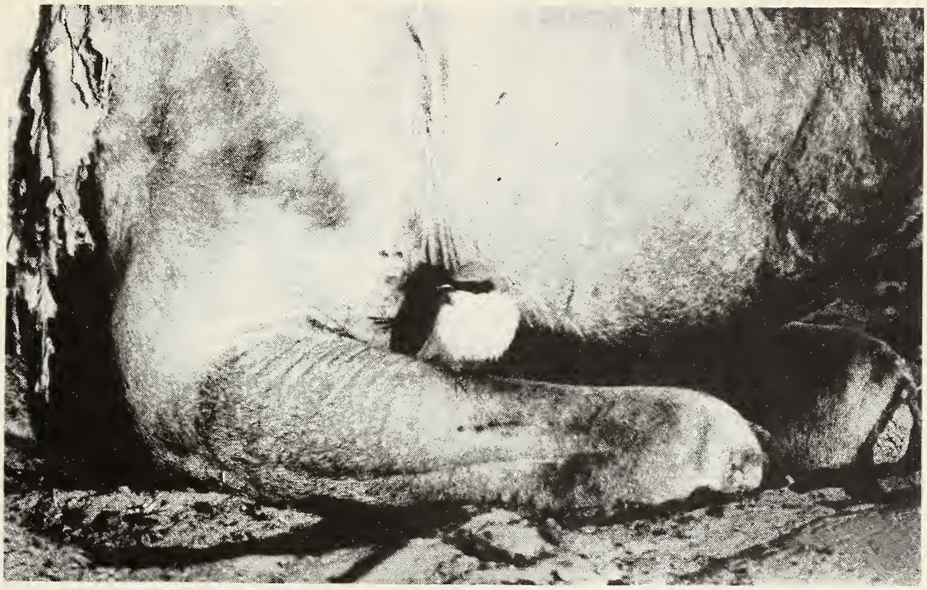
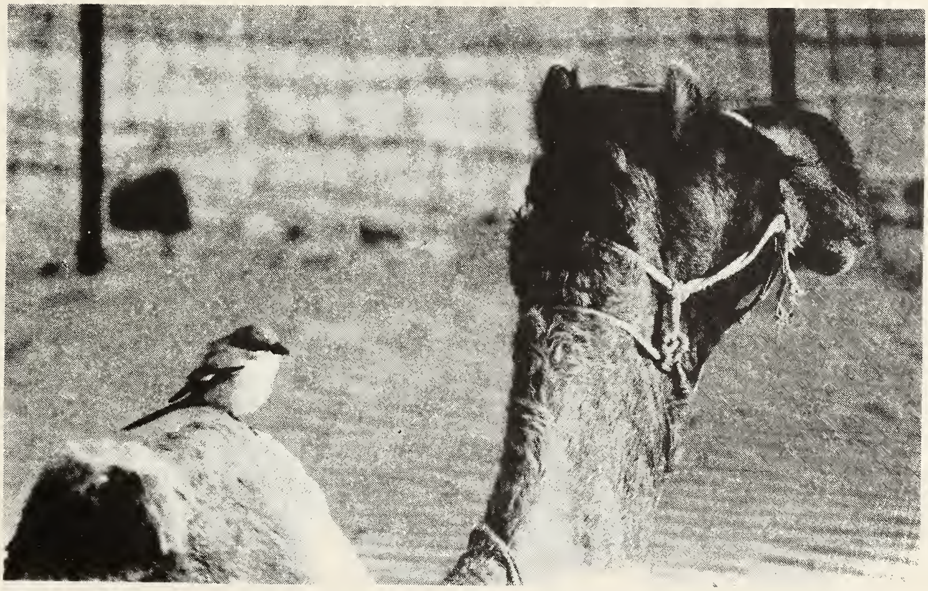
March 27, 1986.





Above: A large grey shrike with a tick in its beak sitting on the leg of a camel.
Below: Shrike perched on camel back.

(*Photos*: Asad R. Rahmani)

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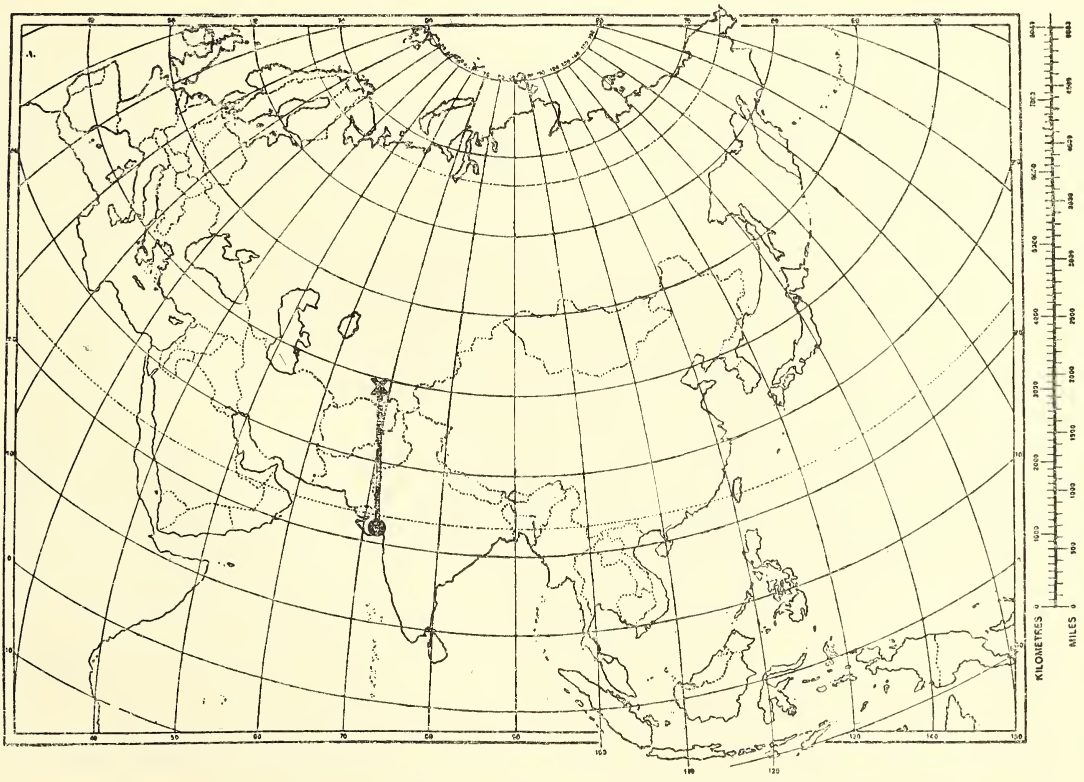
17. RECOVERY OF AN INDIAN GOLDEN ORIOLE (*ORIOLUS ORIOLUS KUNDOO*) IN THE U.S.S.R.

(*With a text-figure*)

During the Society's bird ringing camp at Bhavnagar, Gujarat (21°46′N, 72°11′E) between 12 and 30 September 1961, five Orioles (3 females, 1 male, 1 unsexed) were ringed. Of these one (unsexed) Wing 132 mm was ringed (No. B-2575) on 29th September 1961. The Centre of Ringing and Marking Birds, Moscow, has informed the Society that this bird was recovered at Ordjonikidzeobad (38°29′N, 68°58′E), Tadzhikistan on 10th June 1971.

Dewar (1908) summarizing the information



○ Ringing point. × Recovery point.

Fig. 1.

on the local movements of the Indian resident birds, concluded that the Indian Golden Oriole (*Oriolus oriolus kundoo*) is a migrant. On the other hand Ali and Ripley (1972) state, "Status difficult to define accurately, varies with locality and season between resident, seasonal visitor, local and/or extralimital passage migrant". The recovery of this bird in the USSR is noteworthy specially when there is no definite information on the movements of the Indian Orioles, though Dementiev gives the status as nesting and migratory within the USSR and resident and nomadic in India.

Although this is a single record, it furnishes the first positive proof that the Indian Golden Oriole migrates long distances including the USSR where it also breeds (Dementiev 1970). The bird had travelled approximately 2100 kilometres north of the ringing place and was recovered 9 years 8 months and 16 days later. Incidentally this is longest life span recorded for the Oriole in the wild state.

BOMBAY NATURAL HISTORY SOCIETY,
HORNBILL HOUSE,
SHAHEED BHAGAT SINGH ROAD,
BOMBAY - 400 023,
December 17, 1985.

V. C. AMBEDKAR

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18. ADDITIONAL RECORDS OF THE BLACK DRONGO (*DICRURUS ADSIMILIS*) FEEDING ON BIRDS

The Black Drongo has been occasionally observed to include small birds in its diet. Osmaston (1922) records an incident in which a black drongo preyed on a white eye (*Zosterops palpebrosa*). Two other birds earlier recorded as having fallen prey to the drongo are *Prinia* and *Aegithina* (Ali & Ripley 1983).

While walking through the woodlands of Bharatpur's Keoladeo National Park, we had an opportunity to observe a black drongo feeding on an Indian wren warbler (*Prinia subflava*). The drongo swooped down and captured the warbler, which was foraging in the lower thickets, and carried it away to an *Acacia* tree whereupon it started devouring it. It took exactly 50 minutes for the bird to complete its meal.

A few days later (7.1.85), one of us (U.S.), along with another BNHS biologist Mr. Vibhu Prakash, observed a similar incident in which a black drongo was preying on an Indian cliff swallow (*Hirundo fluvicola*). This was seen on an *Acacia* tree standing by one of the dykes intersecting the wetland. Identity of the prey was confirmed by viewing through a high power telescope.

Both the above incidences happened during the peak of the cold season, a time during which insects are bound to be scarce. A highly insectivorous bird like the drongo is perhaps forced to make an unusual meal of a bird or two as a compensation for the dearth in insect population.

No such event was, however, recorded during the following winter (1985-86). Further observations are required to substantiate the theory that drongos take to preying upon birds more often in winter than in the other seasons.

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C. SIVASUBRAMANIAN

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19. DISPLAY OF THICKBILLED FLOWERPECKER *DICAEUM AGILE*

On 2nd February 1985 in company with Nitin Jamdar, Atul Jamdar and Kiran Shrivastava I visited Karnala Bird Sanctuary. At a point where the path levels out before the final climb to "Fort". I saw a Thickbilled flowerpecker (*Dicaeum agile*) among the branches of an almost leafless tree about 5 m. tall which had many small fruits along the thin upper branches (Earlier I had seen a 'Blue Rock Thrush' *Monticola solitarius* take one of these small round fruit which it swallowed).

While watching the flowerpecker, which was also seen by the other members of the party a second bird flew towards it giving excited twittering calls and fluttered over it. It did this several times and it was evident that it was engaged in a form courtship display and was presumed to be the male of a pair.

As it was displaying, I noted that there was a distinct white line showing as a mesial streak across the crown and down the nape. At one time when its excitement was intense, the centre of the crown seemed to be flecked with white looking like a small brown and white flower. When it moved, away from the presumed female the white was not apparent. My impression was that in display, it could erect and open out the feathers of the crown and nape to show the white feather bases. Identification of the bird was easy as it was in strong sunlight and the dark stubby bill was seen and tail-moving noted, and was confirmed by Nitin Jamdar who is familiar with the species.

7, MURLEY CLOSE,
GEORGE HILL,
CREDITON, DEVON, U.K.,
April 30, 1985.

S. G. MADGE

20. COLOUR SELECTION BY THE BLACKTHROATED WEAVER BIRD *PLOCEUS BENGHALENSIS*

Examination of half-built nests of *Ploceus benghalensis* at the forest plantation Tatarpur (Alwar), Rajasthan, showed that they were decorated with yellow coloured (or some close variant of yellow) floral material around their egg chambers. This type of adornment was associated with the half-built nests only and not with the completed nests. Implantation of yellow floral parts was done on the margin of the egg-chamber and not at the deeper points of the same. The implantation was done on a bed of wet cowdung which was deposited before flower insertion. In a very few cases flower insertion was done without deposition of wet dung. The following floral material has been noted so far (Table 1). From the Table 1 it can be clearly seen that *P. benghalensis* has a definite preference for using yellow floral material to decorate its half-built nest.

Response of ♂ P. benghalensis *to artificial adornment*

Experiments were conducted to judge the response of the male *P. benghalensis* to artificial adornment of its nest. Three males (Pb1,

TABLE 1

No.	Name of plant	Kind of adornment	Colour of adornment	Remarks
1.	*Lantana* sp.	flowers or/and petals	yellow to orange	
2.	*Lagerstroemia indica*(?)	petals	pink	
3.	*Acacia nilotica*	inflorescence	yellow	
4.	*Cucumis melo* var. *momordica*	flowers	yellow	♂ flowers used only
5.	*Momordica dioica*	flowers	light yellow	♂ flowers used only
		pieces of rind of ripened fruit	yellow to orange	
6.	*Acacia nilotica* subsp. *indica* var. *cupressiformis*	inflorescence	yellow	

TABLE 2

No.	Name of plant	Kind of adornment	Colour of adornment
1.	*Momordica dioica*	fresh flower	light yellow
2.	*M. dioica*	fresh flower bud	green
3.	*Acacia nilotica*	fresh flower head	yellow
4.	*A. tortilis*	fresh flower head	whitish yellow
5.	*Tephrosia purpurea*	fresh flower	red
6.	*Commelina benghalensis*	fresh flower	blue
7.	*Acacia senegal*	fresh flower	whitish
8.	*Solanum nigrum*	fresh flower	white

Table 3A

Pb1 in N1

Frequency of removal	Sequence of removal	Name of plant	Colour of flower
Highest	I Removal	*T. purpurea*	red
Moderate	II Removal	*S. nigrum*	white
"	III "	*A. senegal*	whitish
"	IV "	*C. benghalensis*	blue
"	V "	*M. dioica* (flower)	light yellow
"	VI "	*M. dioica* (fl. bud)	green
"	Last "	*A. tortilis*	whitish yellow
Lowest	Not removed	*A. nilotica*	yellow

Table 3B

Pb2 in N2

Frequency of removal	Sequence of removal	Name of plant	Colour of flower
Highest	I Removal	*T. purpurea*	red
Moderate	II "	*A.* senegal	whitish
"	III "	*S. nigrum*	white
"	IV "	*A. nilotica*	yellow
"	V "	*M. dioica* (fl. bud)	green
"	VI "	*C. benghalensis*	blue
"	VII "	*A. tortilis*	whitish yellow
"	Last	*M. dioica* (flower)	light yellow
Lowest	*	*M. dioica*	light yellow

* Although the male removed the flower of *M. dioica*, it picked it up again from the ground and put it back in the nest in its own way.

Table 3C

Pb3 in N3

Frequency of removal	Sequence of removal	Name of plant	Colour of flower
Highest	I Removal	*T. purpurea*	red
Moderate	II Removal	*C. benghalensis*	blue
"	III "	*A. tortilis*	whitish yellow
"	IV "	*A. nilotica*	yellow
"	V "	*A. senegal*	whitish
"	VI "	*S. nigrum*	white
"	VII "	*M. dioica* (fl. bud)	green
Lowest	Last "	*M. dioica* (flower)	light yellow

Pb2 and Pb3) and their half-built nests (N1, N2 and N3 respectively) were selected. In nests N2 and N3 the birds had inserted male flowers of *M. dioica* after heavy deposition of cowdung. In the third nest, N1, a flower head of *A. nilotica* had been inserted without any dung deposition. Taking care not to disturb the floral material already present in the three nests, various flowers, one of each kind, were put in the egg chambers of each nest. See Table 2.

The birds were then observed from within a hide. It was noted that all three birds removed the red flowers of *T. purpurea* first. The experiment was repeated several times. The frequency and sequence in which the flowers were removed differed for the three nests. See Tables 3A, 3B and 3C.

Removal of the flowers was not a continuous activity but done along with the weaving of the nest. The response of the birds to the flowers artificially put in their nests decreased when the experiment was repeated more than twice. After the first, or second time the birds ceased to be much disturbed by the extra floral material placed in their nests. It was also noted that the birds removed the flowers one at a time. However, when two flowers were kept very close together, they were sometimes removed in twos.

Response of female P. benghalensis *to artificial adornment*

During the experiments Nest N2 was visited twice by prospecting females; first by a single female and later on by two. One of the latter entered the half-built nest. She did not touch or seem disturbed by the floral material put there. However, after a few minutes she picked up one flower of *M. dioica* and inserted it in the wall of the egg chamber. When nest N2 was completed, a female (perhaps the same) occupied it for breeding. When there was only one egg in the egg chamber many flowers of various colours were inserted in the egg chamber by me. Some of these were thrown out of the nest by the male and the remaining were later thrown out by the female. This experiment was repeated several times for nest N2 that day. The next morning the nest was found empty; the one-day old egg had also been thrown out of the nest.

Thus it can be said that the male *P. benghalensis* has an affinity for yellow or its close variant colours for decorating its nest. When the nest is artificially decorated, the bird first rejects the red, blue and white flowers. However, if many flowers of each species are inserted together, their removal becomes haphazard. The value of decorating the nest exists until the nest is accepted by a female; after acceptance by her the nest decoration loses its importance.

SATISH KUMAR SHARMA

FORESTER,
I/c MIXED PLANTATION,
TATAR PUR (ALWAR),
RAJASTHAN,
October 15, 1984.

21. SOME COMMENTS ON THE DISTRIBUTION OF THE OSTRICH IN ASIA AND NORTH AFRICA

As an inhabitant of the deserts of Asia, the ostrich *Struthic camelus* is generally considered to have died out by the end of the Pleistocene (Brodkorb 1963) but my attention was recently drawn to a paper by E. D. Ross (1909) which may have escaped the notice of ornithologists. Ross discusses, and attempts to identify a number of descriptions of birds contained in the so-called "Manchu-Chinese Mirror" an exhaustive vocabulary of the Manchu language published in 1771. A number of the birds described are readily identifiable, but a considerable number are not, and some of these may represent aberrant individuals, hybrids, domestic varieties, or frankly fictitious species. On the other hand it is quite possible that some of them may represent species which formerly occurred in eastern Asia, but are now extinct. It is regrettable that so many of the descriptions appear to be vague, however among them a rather unmistakable bird, the ostrich, seems to occur. This is Ross's bird no. 113 which is variously called Ustur Murgh in Turki, Temege coko in Manchu, and T'o chi [using the Wade spelling] in Chinese. All these names seem to mean literally "Camel Fowl" or "Camel Bird" a very reasonable description of the ostrich. According to Ross, the "Mirror" describes the bird thus:-

> "This bird in the Southern Seas and in the south of the province of Fu-Kien. It is very large, measuring six feet in height. It is unable to fly. When full grown, five colours are represented on its body."

Although the last statement is rather obscure, this description, if accurate, can only refer to a large ratite, and the ostrich seems the most likely candidate. As Chinese civilisation probably began in the Hwang-ho river valley, and gradually spread southward; until quite late in history the southern part of the country was probably comparatively sparsely populated. The coastal region of South China (e.g. Fukien) is therefore just the sort of place where a population of a bird such as the ostrich might be expected to linger long after the species had died out elsewhere. Although the date of publication of the "Mirror" (1771) is no proof that the bird was still extant at that date, it does suggest the possibility that a bird of the genus *Struthio* persisted in South China until perhaps the seventeenth or early eighteenth centuries.

A study of the literature of the Indian subcontinent might perhaps reveal similar records there.

After the publication of a previous note (Walters 1982) further confirmation of the probable existence of a population of small ostriches in Northern Africa came to light in the form of an egg brought to the Museum by Mr. Philip Carter who had spent some time in Libya as an employee of an oil concern. Mr. Carter's egg was picked up in the Libyan Desert, having already been exposed both totally and partially for varying periods. The whole of the outer porcellainous layer had been removed, resulting in a matt chalky surface over part of the shell — this chalky surface could easily be scratched with a finger-nail. Subsequently the egg seems to have lain partly exposed for a considerable time, as the rest of the shell was highly eroded, and subsequently polished by wind or sand abrasion to a gloss. This gloss was most pronounced in one small area, and here the shell appeared darker than elsewhere. The egg had a hole in one side which was clearly old, the edges having been smoothed and eroded; and this suggested that the egg may have been used as a water container. When found it was completely buried in the sand, and is now in Mr. Carter's possession.

It measured 147 x 126 mm and is therefore comparable in size with the eggs of *Struthio camelus syriacus* and *S. c. spatzi* (Schönwetter 1960). Although it also falls within the range quoted by Schönwetter (142-175 x 120-145 mm) for *S. c. camelus* it is quite possible that Schönwetter's figures may be biased to the bottom end of the range by the inclusion of one or more eggs of this small form.

MICHAEL WALTERS

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March 6, 1985.

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22. MORTALITY FROM A HAIL-STORM AT THE KARERA BUSTARD SANCTUARY, MADHYA PRADESH

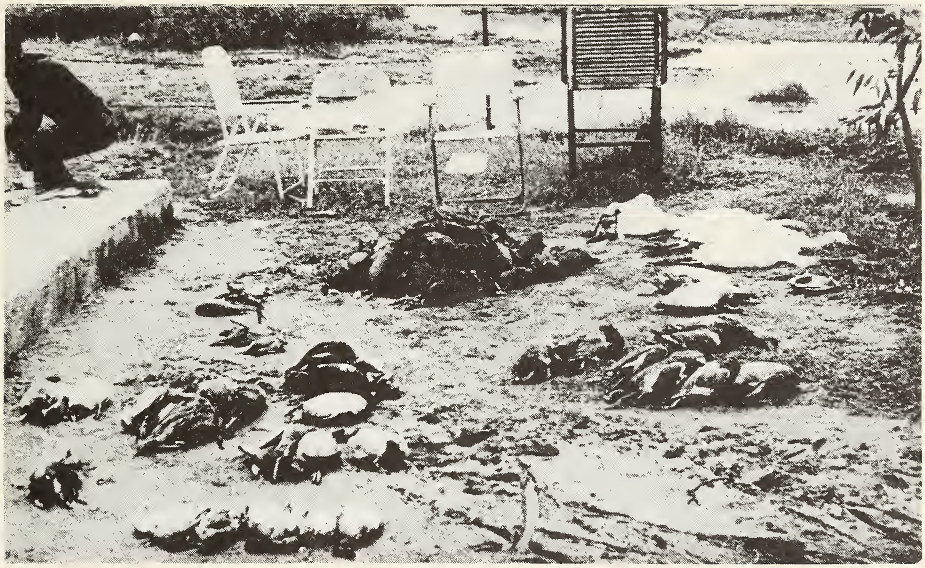
(*With a plate*)

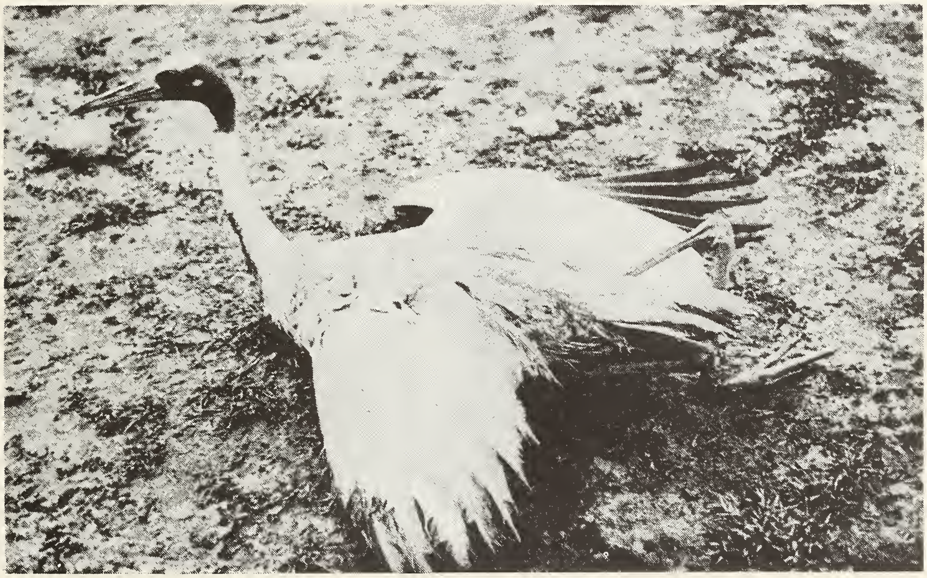
Natural calamities like floods, forest fires and earthquakes are known to cause considerable damage to living organisms. A similar natural calamity was witnessed by us recently which created panic and confusion leaving behind a trail of destruction.

On 10th February 1986, around 1500 hrs an unprecedented hail-storm lashed parts of Shivpuri district, Madhya Pradesh. The effect of this hail-storm was very severe in the Karera Bustard Sanctuary (lat. 25°30′ to 25°40′N and longitude 78°5′ to 78°12′ E). The hail-storm lasted for about 25 minutes. The weight of the hailstones varied from 250 to 350 gm.

The effect of the hail-storm was very severe around the Diyala Jheel situated in the Karera Bustard Sanctuary. The Jheel at that time sheltered a large number of migratory waterbirds like ducks, geese and smaller waders. As the hail-storm lashed, the birds tried to take off and escape but were dashed to the ground by the heavy hailstones. According to our estimate, about two thousand waterbirds alone died or were badly injured. Soon after the storm abated, the villagers from nearby villages rushed towards the jheel and carried away dead and dying birds in gunny sacs. Dead birds were strewn all over the place.

Next morning one of us (EDC) with the help of a bird trapper collected some of the dead bodies of birds from the jheel, recovering 130 of them. Most of them had been killed from injury to the wings, rump and head and neck. Some had broken wing bones jutting out. A few had their eyes gouged out. We saw a Sarus Crane (*Grus antigone*) immobilised





Above: Piles of birds killed by the hail-storm. *Below*: A sarus crane with wings broken by the hail-storm.
(*Photos*: Asad R. Rahmani)

with broken wings and feet (Plate I). It was calling helplessly and it died after a day. A Demoiselle Crane (*Anthropoides virgo*) was found limping. Three whitebacked vultures (*Gyps bengalensis*) also died. Apart from birds, two blackbuck (*Antilope cervicapra*) and a good number of livestock also perished. Two shepherds who were out in the field were hit but they managed to save their lives. The hail-storm caused considerable damage to the standing wheat and groundnut crops.

Given below is a list of birds that were collected by us from the jheel on 11.2.1986 in the morning between 1000 and 1200 hrs.

The list represents but only a small percentage of the birds killed. Since these were entangled in the grass in deep water the villagers were unable to collect them. Many birds with deep gashes could be seen fluttering around the whole sanctuary for a couple of days. In all it was a pathetic sight.

	Species	No. of birds
1.	*Phalacrocorax fuscicollis*	1
2.	*Threskiornis aethiopica*	1
3.	*Platalea leucorodia*	6
4.	*Anas acuta*	5
5.	*Anas crecca*	7
6.	*Anas strepera*	5
7.	*Anas penelope*	2* F 59014
8.	*Anas clypeata*	1
9.	*Netta rufina*	9
10.	*Aythya ferrina*	3
11.	*Aythya fuligula*	6
12.	*Fulica atra*	76
13.	*Hydrophasianus chirurgus*	2
14.	*Vanellus leucurus*	2
15.	*Tringa erythropus*	1* 1B46852
16.	*Gallinago gallinago*	1
17.	*Calidris testacea*	1* AB 117351
18.	*Philomachus pugnax*	1* B 64617
19.	*Streptopelia tranquebarica*	1△
20.	*Streptopelia decaocto*	2△
21.	*Psittacula krameri*	1△

* denotes birds with BNHS rings.
△ denotes collected from outside the jheel.

BOMBAY NATURAL HISTORY SOCIETY,
HORNBILL HOUSE,
SHAHEED BHAGAT SINGH ROAD,
BOMBAY 400 023,
April 2, 1986.

E. P. ERIC D'CUNHA
ASAD AKHTAR

23. INTIMIDATION AMONG WATERBIRDS AT BHARATPUR

On 28th February 1985 at about 16 hours, we were watching a mixed flock of birds feeding at the Keoladeo Temple at the Keoladeo Ghana National Park, Bharatpur. The mixed flock included purple moorhens, whitebreasted waterhens, pond herons, little egrets, cattle egrets, median egrets, glossy ibis, purple herons, grey herons, a blacknecked stork, Sarus cranes, Siberian cranes, whitetailed lapwings, and some ducks, amongst others.

Whilst most of the other bird species were engaged in feeding, some competition for food was observed between the several pond herons at the site. Some aggressive behaviour was also observed between the purple moorhens.

One of the more successful pond herons suddenly came up with a prize catch — a black catfish over six inches long. Perhaps apprehensive of the fact that the other pond herons might deprive him of this catch, he quickly flew off with the fish, which, held at right angles to his beak, was making a valiant attempt to escape.

Unfortunately, though the pond heron succeeded in evading the unwelcome attentions of his comrades, a purple heron decided to investigate. Deciding that the catfish was too much of a mouthful for the pond heron, the purple heron attacked the pond heron, who promptly dropped the fish and sat down with a loud squawk. The purple heron swooped down on the fish and picked it up without alighting, but unfortunately for him, the pond heron's cry had attracted the attention of a grey heron and a blacknecked stork. We were treated to the rare sight of the purple heron being chased by the grey heron which in turn was being chased by the blacknecked stork. Flying at a height of not more than fifty feet, the purple heron made a valiant attempt to escape by circling back. The grey heron suddenly decided that discretion was the better part of valour and gave up the chase after about 30 seconds, flying off at a tangent, leaving the field clear for the black-necked stork. Realizing that the blacknecked stork was not going to give up so easily, the purple heron dropped the fish and settled down at a distance, while the blacknecked stork dived triumphantly to retrieve the fish.

Alas, there is many a slip 'twixt the cup and the lip, for this time, the fish had fallen in one of the shallow marshy pools. Though the blacknecked stork settled down very quickly and made a number of attempts to locate the fish, he was unable to do so. When we left half an hour later, he was still jabbing away.

Intimidation doesn't always pay!

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DEBI GOENKA

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HETA PANDIT

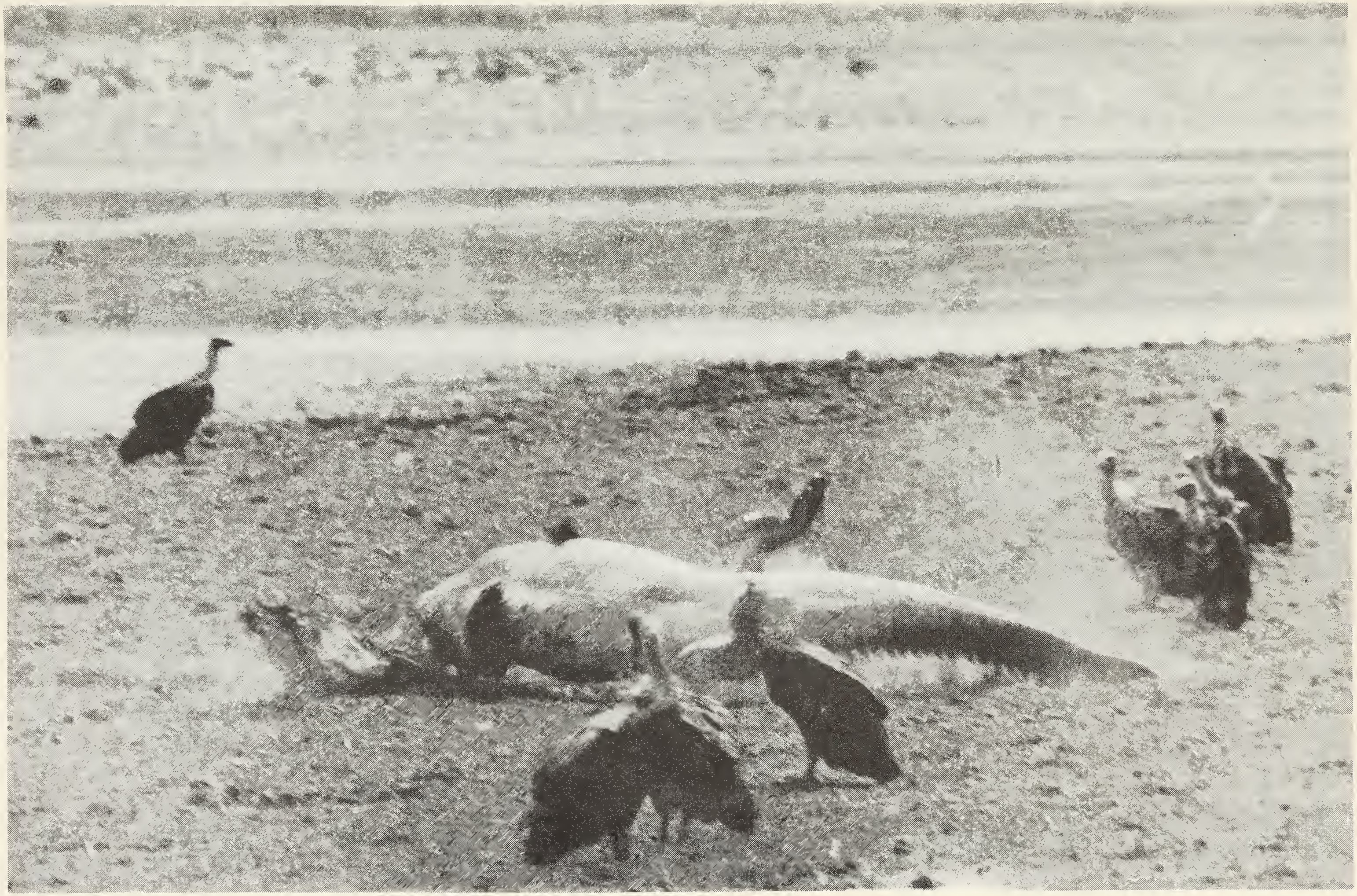
24. NOTE ON THE STRANGE BEHAVIOUR OF A MARSH CROCODILE (*CROCODYLUS PALUSTRIS*)

(*With a plate*)

On 3rd of June, 1986, I was at the Raj Bagh Lake in Ranthambore National Park observing the activity around a female sambar kill of a tiger on the edge of the lake. The kill was half eaten and vultures were already on it.

Around 2.00 p.m. a crocodile came out of the water, went to the dead sambar and after a spell of inactivity, took three bites out of it. Soon this crocodile was followed by another who settled down near the kill on the opposite side. The first returned to the water and so did the second without eating anything.

The third crocodile (all of them were around ten feet in length) came out of the water, went to the kill, caught the dead sambar by the neck and spun round five to six times with the kill still in its mouth. The crocodile came to rest with all its feet in the air and remained in this position for a few seconds before turning right side up on to its feet. Soon thereafter, this crocodile also went back into the lake without attempting to eat anything from the kill.



Crocodile spinning with the kill in its mouth.
(*Photo*: Udaybhanusinh)

I have never seen such behaviour and nor can I explain it in any way apart from the possibility of the crocodile repeating on the ground certain motions which it performs in the water. It appeared to me to be an attempt of the crocodile to dismember the kill. However, in this case the latter remained intact after the crocodile's efforts.

The accompanying photograph (Plate I) shows the crocodile spinning round with the kill in its mouth, it is in "mid-air" so to speak.

No. 1, Mansingh Road,
New Delhi-110 011,
July 8, 1986.

DIVYABHANUSINH

25. IDENTITY OF "BAHEL SCHULLI" OF HORTUS MALABARICUS

"Bahel Schullii" was the local name used by Draakestein van Rheede for the acanthaceous plant presently known in our Indian Floras as *Hygrophila auriculata* (Schumach.) Heine. The first valid binomial used for this taxon was *Barleria longifolia* Linn. (Amoen. Acad. 4: 320, 1759). This species was placed under the genus *Hygrophila* R. Br. as *H. spinosa.* T. Anders, by its author on taxonomical grounds. The specific epithet *longifolia* is occupied by another distinct species in that genus by *Hygrophila longifolia* Nees (1847) and therefore a new combination *H. auriculata* (Schumach.) Heine (Kew Bull. 16: 172, 1962) was proposed based on the earlier name *Barleria auriculata* Schumach. (Schumach. & Tonn. Beskr. Guin. Pl. 285, 1827).

Francis Hamilton (1824), unaware of the earlier Linnean binomial *Barleria longifolia* Linn. — for this plant thought that this well described and figured plant of Rheede's Hortus Malabaricus is devoid of any valid binomial and proposed a new binomial *Bahel schulli* Hamilt. (Trans. Linn. Sco. Lond. 14: 289, 1824), treating *Bahel* as generic name and *schulli* as specific epithet, giving pre-Linnean identity of the species and a first-hand fresh description. However, Hamilton's binomial has escaped the attention of the modern taxonomist because of the later generic homonym *Bahel* proposed by Hamilton.

In fact Rheede (Vol. 9: 169, t. 87, 1689) had used the orthographic varient of local name "Bahel tsjulli" for another distinct species belonging to family Scrophulariaceae, now placed in genus *Artenema* Don.

Adanson (Fam. Pl. 2: 210, 1763), however had used Generic name *Bahel* for Scrophulariaceous "Bahel tsjulli".

Hamilton's generic name *Bahel* is therefore later homonym of Adanson's name. However his binomial *Bahel schulli* Hamilt. is validly published and according to Article 68.1 its specific epithet *schulli* is available for use in genus *Hygrophila* R. Br., which has priority over *Barleria auriculata* Schumach.

We, therefore propose a new combination *Hygrophila schulli* (Hamilt.) comb. nov. (Trans. Linn. Soc. Lond. 14: 289, 1824).

Basionym: *Bahel schulli* Hamilton.

Hamilton also mentions a variety of this species having pure white flowers. There is no subsequent record of this species having seen in pure white flowers. We have recently collected this pure white-flowered variety at Nandur-Madhmeshwar.

ALCHEMIE RESEARCH CENTRE,
THANE-BELAPUR ROAD,
THANE-400 601.
M. R. ALMEIDA

BLATTER HERBARIUM,
ST. XAVIER'S COLLEGE,
BOMBAY-400 001,
October 22, 1986.
S. M. ALMEIDA

26. NOTES ON IDENTIFICATION OF SOME UNIDENTIFIED PLANT-SPECIES IN HORTUS MALABARICUS

During our studies on plants of Western Ghats (Maharashtra) we had the opportunity to go through the pioneering work on Indian plants by Draakestein van Rheede (1678-1693). In spite of a number of attempts to identify and name the species figured and described in the 12 volumes of van Rheede's work, a number of species still lack proper identifications and good nomenclatural concepts. We have tried to interpret the plates in these volumes and assign them correct botanical names. The following three are unknown or obscurely known in modern taxonomical terms and are attempted below:

1. KATOU-THEKA (Catu-tekka in English)
Ranpaphla (Brahmin).
Rheede, Hort. Mal. 4: 59, t. 28, 1683.

In the post Linnean period, Poir (Lamarck Encycl. 5: 1, 1804) identified this figure as belonging to a species of *Psychotria.* Hamilton while giving the commentary on this species concluded that, as suggested by Wildenow, Katou-theka is the same 'cupi' of another figure of Rheede (Hort. Mal. 2: 37, t. 23, 1679); he identified it as *Webera corymbosa* Willd. After careful study of van Rheede's figure and the description, we have come to the conclusion that the Rheede's species represents the Rubiaceous plant *Psychotria dalzelli* Hook. f.

We justify the identity of this figure as *Psychotria dalzellii* Hk. f. on the bases of following reasons:

1. Leaves in this taxon are given as more or less spatulate as in *Psychotria dalzellii* Hk. f.
2. Inflorescence is a terminal cyme, the cyme branches whorled, the lower in whorls of 4, subtended by 4 large bracts.
3. Flowers crowded at the tips of branches.
4. Fruit sub-globose, crowned by calyx limb, subtended by persistent bracts.

Typical specimen: S. M. Almeida 420, Charatha-Savantwadi (25-7-77). J. F. Fernandes 1626 — Yellapur N. K. (1-6-1950), (BLAT).

We do not concur with Hamilton (1835) that the Rheede's figure belongs to *Webera corymbosa* due to following reasons:

1. Leaves in *Webera corymbosa* Willd. are not spatulate; they are linear-lanceolate or oblong-lanceolate.
2. Inflorescence terminal, compound dichasial cyme, not arising in whorls of 4; not subtended by large bracts.
3. Fruit globose, not subtended by large bracts.
4. *Webera corymbosa* Willd. is already separately figured and described as 'cupi' by van Rheede, (Vol. 2: 37, t. 23, 1679).

2. BEN-TEKA (Malayalam)
Saili (Brahmin).

Rheede Hort. Mal. 4: 63, pl. 30, 1683.

The Figure of this species in Hortus Malabaricus is botanically not well represented, but after studying the figure and the text, we have come to the conclusion that it belongs to the species presently known as *Hymenodictyon excelsum* Wall.

Lamarck (Encycl. 1: 401, 1785) gave the description of this species under its local name 'ben-teka' without any specific epithet and without a validly published generic name. Dennstaedt provided the botanical binomial *Kasailo racemosa* Dennstd. which is also considered as an invalid name (see Article 42.IC of ICBN). The first valid binomial for the taxon was published by Roemer & Schultes (1819) as *Ben-teka rheedii* Roem. & Schult. (Syst. 4: 706 1819). However, this binomial was confused as belonging to family Apocynaceae due to *Ben-teca* Adanson (Fam. 2: 166, 1763), *Ben-teka* Adanson (Fam. 2: 525, 1763). These were considered congeneric and equated with *Ambelania* Aubl. (Apocynaceae).

There are a number of defects in Rheede's figure which has made this taxon unrecognizable to the commentators. We enumerate the following few defects which have made the figure unrecognizable —

1. Fruits in some cases have been shown blunt at apex; whereas they are always acute at the apex when they are young or unopened.
2. Fruits are shown without stalk borne on the inflorescence branches, but actually the fruits are stalked and do not originate in clusters as shown in the figure.
3. The leaves are shown as alternate or as if they are coming only from one side of the stem; whereas they are typically opposite in actual plants.

We could at once recognize this plant as belonging to presently known species *Hymenodictyon excelsum* Wall. due to the following reasons —

1. Leaves broadly ovate, long-petioled, acuminate at apex, narrowing to the base to the petiole.
2. Inflorescence a long raceme, flowers in clusters, shortly pedicellate; style exerted, stigma large, capitate.
3. Fruit ellipsoid, acute at apex, on decurved stalks.

But for expert field knowledge of this species, it is impossible to place this taxon in its proper place. We cannot understand the basis of Francis Hamilton (1825) placing this taxon in "The order" Solanaceae.

As the identity of the taxon is clear to us now, we find the earliest validly published name for this species is *Benteka rheedii* R. & S. Therefore, we propose the following new combination for this taxon.

Hymenodictyon rheedii (R. & S.) comb. nov.

Basionym: *Benteka rheedii* R. & S. Syst. 4: 706, 1819.

Benteca Adanson is heterotypic generic homonym and orthographic variant of this taxon.

In the latest code of ICBN, on page 411, in entry No. 8197, we find *Benteca* Adanson is given as a rejected name (Nom. reiiciendum) against *Hymenodictyon* Wall. ex Roxb. and they are shown as taxonomic synonyms based on different types. This entry needs two corrections in view of our findings:

1. *Benteka* Adanson (Fam. 2: 525, 1763) based on the type of Rheede Hortus Malabaricus 4: 63, pl. 30, 1683 is congeneric with *Hymenodictyon* Wall. ex Roxb. and not with *Benteca* Adanson (Fam. Pl. 2: 166, 1763), which is based

on different type species *Benteca odorata* Rafin.

2. *Benteka* Adanson is not only a taxonomic synonym, but it is a nomenclatural synonym of *Hymenodictyon* Wall. ex Roxb.

Typical specimen — K. V. Shenoy: 3719 — Mumbra (9-7-1954) (BLAT).

3. SUNDARI: Rheede, Hort. Mal. 5: 79, t. 40, 1685.

In our opinion this taxon belongs to the species known today as *Ehretia laevis* Roxburgh. It is called 'Sundari' by van Rheede, but there is no indication to suggest whether it is the Malayalam name or the Brahamin name of the species. It was described as 'Kaka-ponna' allied to genus *Euonymus* (Celastraceae) by Poiret (Ency. 8: 228, 1834) and was given the binomial *Sundaria cranganoorensis* by Dennstaedt. Dennstaedt's name is invalid under Article 42.IC of ICBN. Hamilton identified this as a species of Rhamnaceae, where as Don and Poiret thought it to be belonging to Celastraceae. Ultimately, nobody so far has correctly identified this plant belonging to Ehretiaceae.

The plant when in bloom, is very beautiful and it attracts number of bees and other insects. The local name sundari might be indicative of aesthetic beauty of this species.

Typical specimen: Santapau—18396 Waghai-Dangs forest (12.3.1954), (BLAT).

We are grateful to the authorities of Blatter Herbarium for providing facilities to work, and to Dr. (Mrs.) A. R. Daruwalla for making necessary corrections in the manuscript.

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ST. XAVIER'S COLLOGE,
BOMBAY 400 001,
November 4, 1986.

S. M. ALMEIDA

27. PROLIFERATION IN *OPUNTIA DILLENII* (KER-GAWLER) HAW.

(*With a photograph*)

Opuntia dillenii (Ker-Gawler) Haw., an introduced cactus from Californian Peninsula, is frequent in various places of Deccan Plateau, along hedges and wastelands; it is also occasionally cultivated in gardens as an ornamental plant. In one of the plants growing in our garden mature fruits are never produced and young fruits wither and fall off after some time. However, in a few cases, surprisingly, I observed the development of normal flattened joints with spines from the fruit when it is still attached to the mother plant. On critical observation, these fruits showed no viable seeds but only sterile ovules. Sections of such fruits revealed that proliferation took place from the receptacular part of the inferior ovary. The ovary, thus, functioned as a joint of the stem. These fruits never ripened and remained green without any significant enlargement.

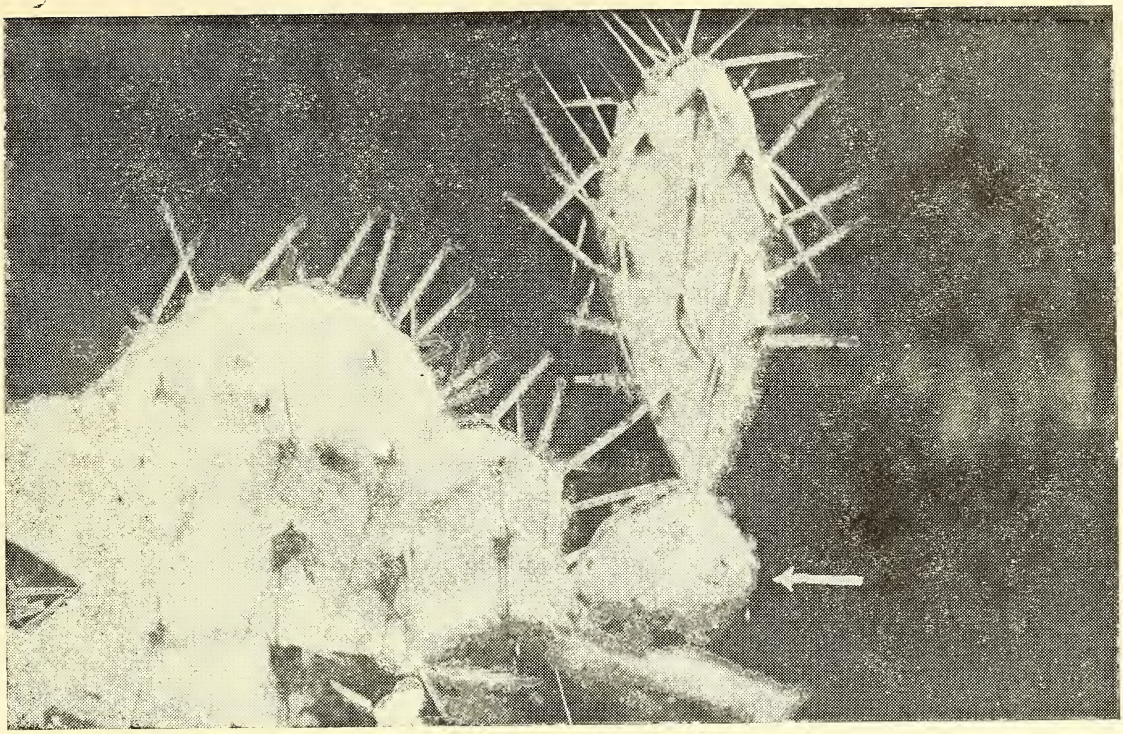

Photo. 1. *Opuntia dillennii* (Ker-Gawler) Haw. showing the development of normal joints from the fruit (arrow).

The inferior ovary, in members of Cactaceae, is commonly interpreted as having originated by the sinking of the gynoecium into the floral axis (receptacle) and the present observation is a strong evidence in favour of this interpretation.

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KARNATAKA,
May 30, 1986.

ACKNOWLEDGEMENT

The photographic assistance rendered by Dr. N. A. Madhyastha is gratefully acknowledged.

K. GOPALAKRISHNA BHAT

28. A NEW EXOTIC SOLANACEOUS WEED IN OLD WORLD TROPICS

(*With a plate and three text-figures*)

INTRODUCTION

Plant migrations have not only enabled human civilizations to flourish in different continents of the globe, but also caused natural calamities that led to human migrations (Baker 1974, Hutchinson 1965). These catastrophies are the consequences of conversion of productive ecosystems into non-productive ones due to invasion of aggressive exotic weeds and the outbreak of epidemics of plant, animal and human diseases through the accidental introduction of virulent pathogens and pests from one country into another. The former is exemplified by the rapid invasion of life supporting aquatic systems by the obnoxious South American weed — *Eichhornia crassipes* Solms, resulting in the eutrophication of lakes and in the disruption of ecological balance; the latter is exemplified by another American weed, the congress grass (*Parthenium hysterophorus* Linn.) causing allergy to animals and humans; and the damage caused by the pests is best illustrated by the crop losses due to accidental introduction of weed seed carrying virus and bacterial diseases. These facts demonstrate that plant migrations have played havoc with human civilizations.

Weeds have been the subject of much research because of their importance in agriculture and horticulture (Baker l.c.). Weed floras include both native and immigrant weeds. The naturalized exotic weeds (aliens) often displace native flora and cause an ecological disturbance. In fact, in tropics a genus (or even family) where weediness is not prevalent,

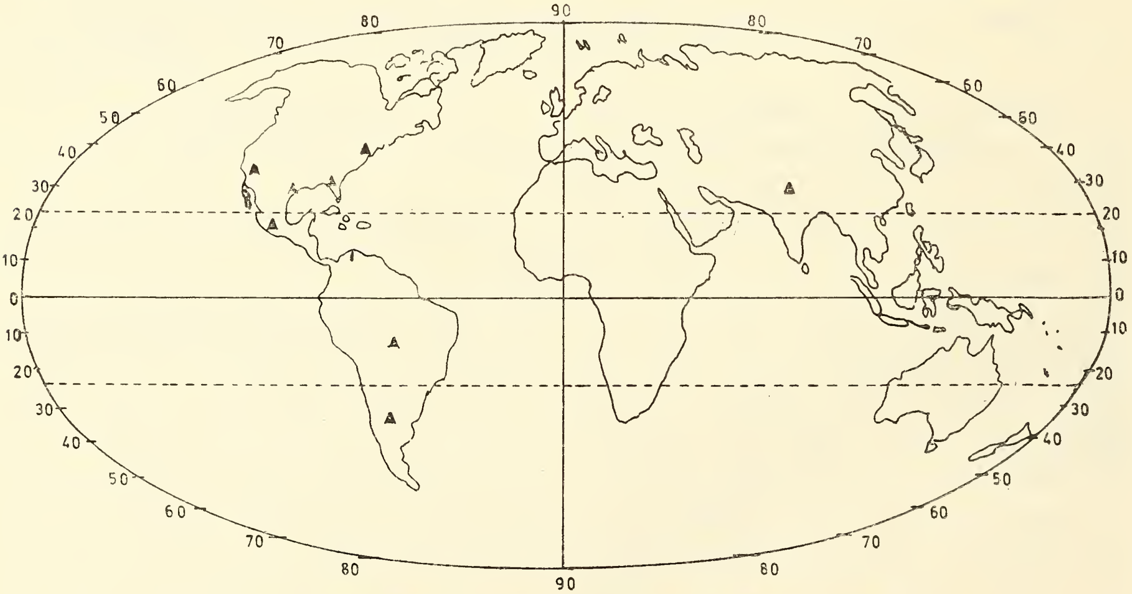

Fig. 1. Map showing distribution of *Petunia parviflora* Juss.

may contain an occasional species with an evolved combination of characters that have enabled it to 'hit the weed jackpot' and spread widely with human aid (Baker l.c.). This aspect of evolution of weeds is evident from the weeds of South American origin in India, which is represented by the members of Amaranthaceae, Asteraceae, Malvaceae, Solanaceae, and others. Within Solanaceous weeds, a majority of them belong to *Solanum* and a few of them are represented by the species of *Physalis.* The genus *Petunia* comprises species which are chiefly American in distribution, the nomenclature of the genus itself having been derived from the South American aboriginal name, 'Petu-nia' (Bailey 1944). The genus contains 40 species, mainly South American in occurrence, among which *Petunia par-*

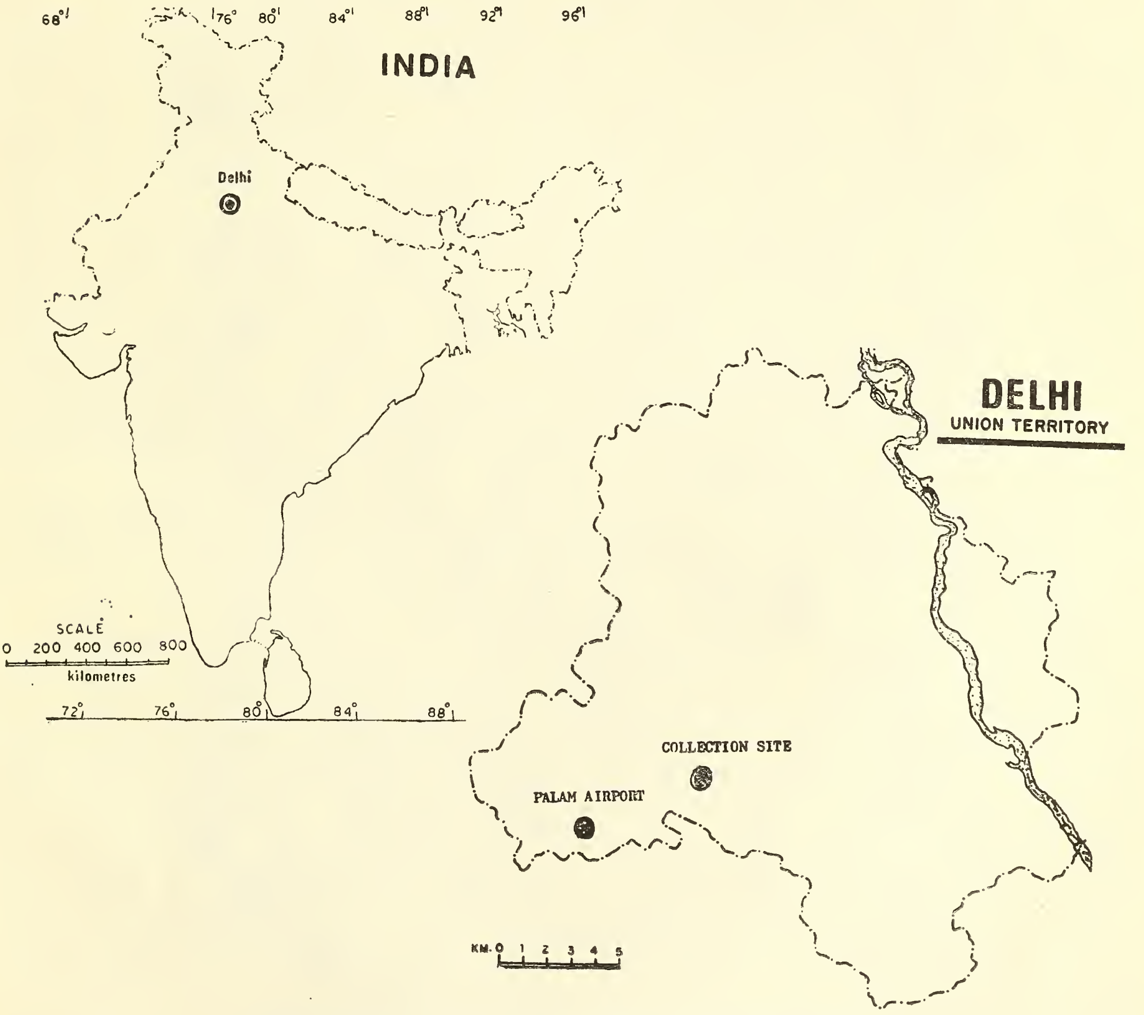
68°
76°
80°
84°
88°
92°
96°
INDIA
Delhi
SCALE
0 200 400 600 800
kilometres
72°
76°
80°
84°
88°
DELHI
UNION TERRITORY
COLLECTION SITE
PALAM AIRPORT
KM. 0 1 2 3 4 5

Fig. 2. Showing Palam Airport, Delhi and collection site.

viflora Juss. is a remarkable species with a wide range of disjunct distribution (Fig. 1), and is of South American (Brasilian) origin; it occurs as a common weed in the dry areas of South Western, Central, North Eastern and North Western United States (D'Arcy 1978, Munz & Keck 1959). The genus contains many species of horticultural value, the cultigen, *Petunia hybrida* Vilm., being grown in Indian gardens too. But the occurrence of a weed species of *Petunia* — *P. parviflora* Juss., is reported here for the first time from the Old World tropics.

OBSERVATIONS AND DISCUSSION

In the course of our investigations on the Flora of Delhi, we encountered a population of plants in cultivated fields of Purana Basant village located about 6-8 km east of Palam — the International Airport, at New Delhi (Fig. 2). Detailed examination of these plants indicated that the population represents an unusual taxon not reported so far from the Indian sub-Continent, and resembles superficially, *Bacopa* of Scrophulariaceae. Further studies revealed that the plants did not belong to Scrophulariaceae, but could be referred to Salpiglossidae of the family Solanaceae. Since we could not identify the species locally, the specimens were sent to Dr. William D'Arcy (Missouri Botanical Garden), Dr. Michael Nee (New York Botanical Garden) and to Dr. Dan Nicolson (Smithsonian Institution, Washington) all of whom are authorities on Solanaceae and who have identified the species as *Petunia parviflora* Juss. of Salpiglossidae of Solanaceae.

The occurrence of *P. parviflora* the type species of the genus, in the Indian subcontinent gives a clue that it may also occur elsewhere in the Old World tropics as an accidental introduction. The fact that the population is restricted to a field close to the International Airport suggests that the seeds of *P. parviflora* might have arrived alongwith the air cargo. It is now spreading fast in the nearby fields. The observations demonstrate that the species is of recent introduction and is now getting naturalised as an alien species. Since it forms a component of weed flora of agricultural fields, it is essential to eradicate it right in the initial stages before it could spread to other parts of the country and to neighbouring countries in the sub-continent.

Petunia parviflora is a creeping herb, rooting at nodes and often forming mats (Plate, Fig. 3). It is usually associated with other weeds such as *Chenopodium*, *Amaranthus*, and *Portulaca*. Besides vegetative reproduction by stem stolons, the species produces copious seeds. On an average, a single plant produces about 60 to 80 seeds per capsule, which have considerable dormancy. The seedlings usually emerge during the months of March/April and the plants flower and fruit in the months of May-June and this continues till the advent of winter.

In order to facilitate easy identification of the species, diagnostic morphological features are provided here.

Petunia parviflora Juss. (Fig. 4)

Creeping annual herbs, rooting at nodes; branches glandular-hairy, with purple, 2-3 celled hairs, particularly when young. Stems terete, yellowish-green when dry. Leaves alternate in the lower part and opposite in the upper part, often fascicled because of condensation of internodes, obovate, spathulate, subsessile or shortly petioled, obtuse or obtusely acute at apex, entire, glandular ciliate, glandular hairy on both surfaces, with a prominent midrib, 4-20 mm x 1-4 mm. Flowers solitary axillary, bracteate, upto *c* 10 mm long; subsessile or shortly pedicellate, pedicel

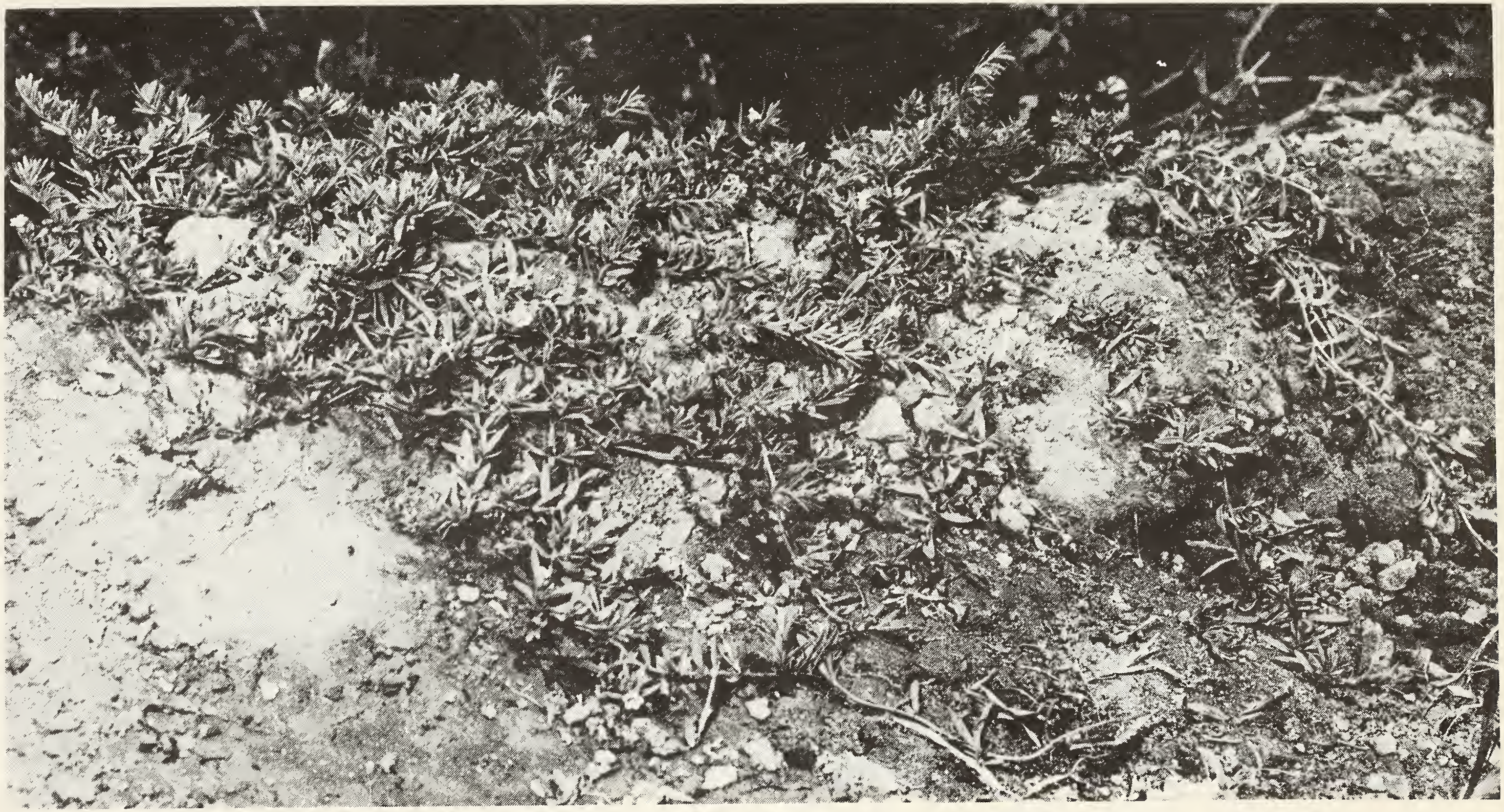

Fig. 3. *Petunia parviflora* — a creeping herb.

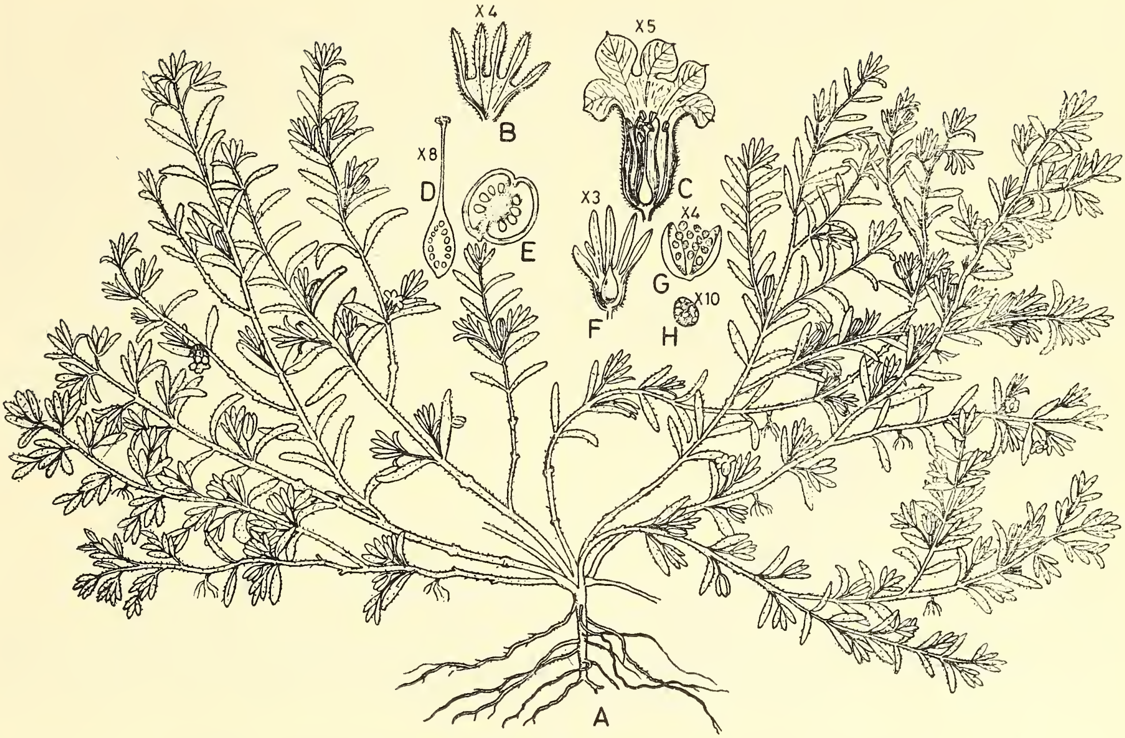

Fig. 4. *Petunia parviflora* Juss.
A. Habit; B. Calyx; C. Flower L. S.; D. Pistil; E. Ovary C. S.; F. Capsule enclosed in calyx; G. Capsule-open; H. seed.

upto *c* 6 mm long, glandular hairy. Calyx 5 lobed, glandular hairy, lobes oblong, broader towards the apex, obtuse, unequal in size, posterior one being larger, 2-6 mm long, and 0.5-1 mm broad, 1-nerved. Corolla slightly longer than the calyx, upto 10 mm long, infundibuliform; tube greenish outside, yellowish within, 1-2 mm broad; throat glabrous; lobes 5, pink, slightly irregular, upper 3, lower 2, roundish, acuminate, glandular hairy on the outer surface, glabrous within, 2 x 2 mm. Stamens 5, included, inserted at the base of corolla tube, unequal, longer ones 4-5 mm, shorter one 3-4 mm; anthers bright yellow, glabrous, 2 celled, cells distinct, parallel, divergent at base, dehiscing longitudinally and laterally, posterior ones touching the stigma; pistil 6 mm long; ovary hypogynous, pink, glabrous, ovoid, 1 mm long, 2-carpelled; ovules many on swollen axile placenta; placenta somewhat oblique, the septum pushed towards the posterior wall of the ovary; style simple, 4-5 mm long, dilated upwards; stigma capitate, creamish, slightly 2-lobed. Capsule enclosed within the persistent, enlarged calyx, brown, glabrous, ovoid, septicidal, 2-valved, valves entire, dehiscing from the top, separating from the central column, 4 mm long. Fruiting calyx upto 15 mm and 0.5 to 1 mm broad. Seeds many, about 60-80 in each fruit, reddish-brown, somewhat triangular, lenticular, faveolate, 0.5-0.7 mm in diameter, with slightly curved embryo.

Specimens examined: INDIA: New Delhi, Purana Basant, 21-5-1981, Viswanathan & Singh 575 (RHMD).

ACKNOWLEDGEMENTS

Our sincere thanks are due to Dr. Dan Nicolson (Smithsonian Institution, Washington, USA), Dr. William D'Arcy (Missouri Botanical Garden, USA) and Dr. Michael Nee (New York Botanical Garden, N.Y., USA), for the identification of the specimen. We are grateful to Dr. C. R. Babu (Botany Dept., University of Delhi, India) for his valuable suggestions and guidance in the preparation of this paper. We are indebted to the Editor-in-Chief and Mrs. K. Ramachandran of the Publications & Information Directorate, for providing all facilities and constant encouragement.

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HUTCHINSON, J. B. (1965): Crop Plant Evolution. Cambridge Univ. Press. London.

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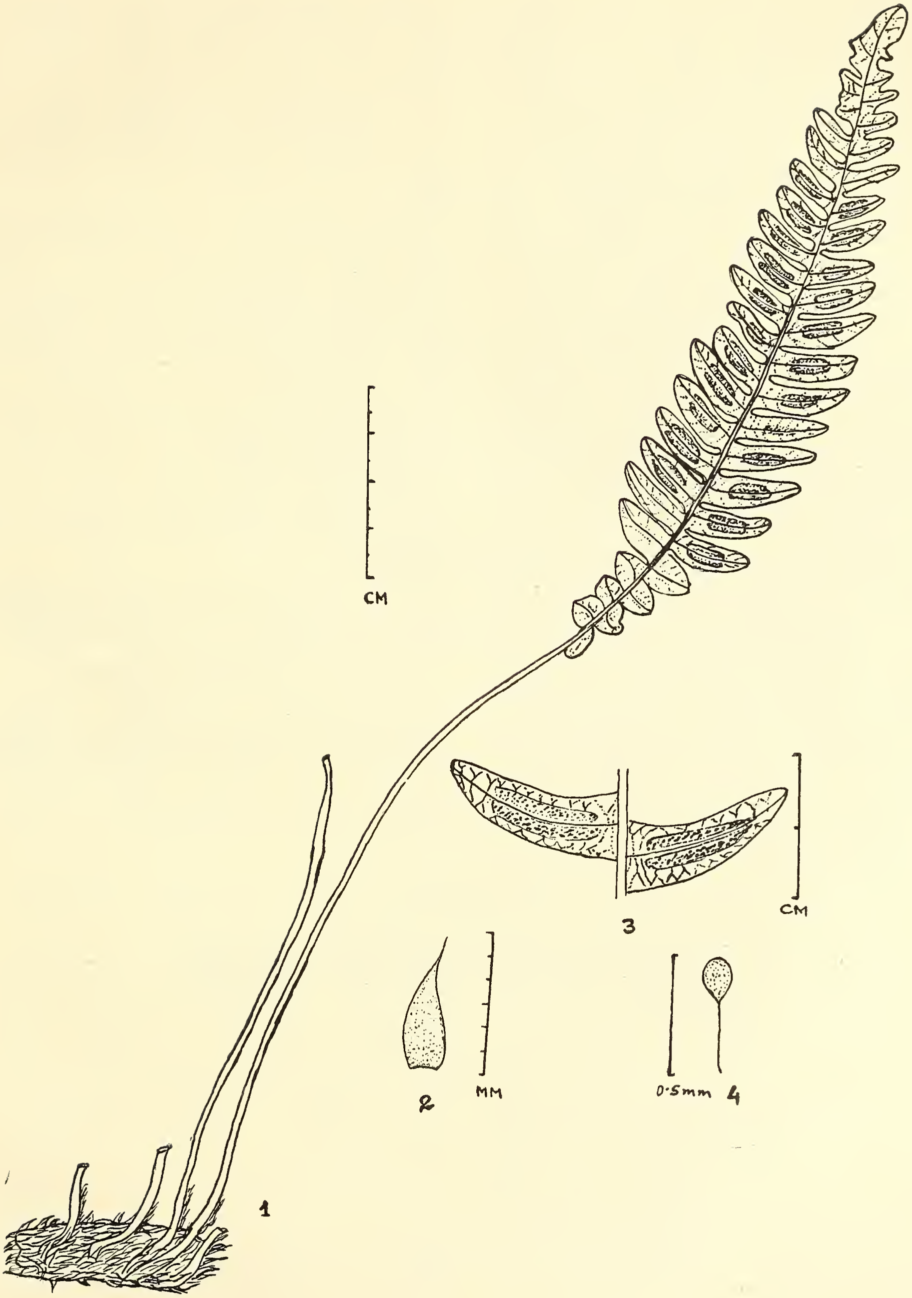
29. REDISCOVERY OF *BLECHNIDIUM MELANOPUS* (HOOK.) MOORE (BLECHNACEAE) — A RARE FERN FROM ARUNACHAL PRADESH, INDIA

(*With four text-figures*)

During the course of botanical exploration of Lower Subansiri District in April, 1980, for preparation of District Flora, I collected this rare and noteworthy fern from subtropical primary forest. Beddome in his hand book of ferns of British India (1883) listed this plant from Khasia hills of Meghalaya and Taiwan. There is no other record of the occurrence of this taxon from anywhere else. It is now being reported for the first time from Arunachal Pradesh. The present report is also significant as this plant is collected after a considerable lapse of time. Besides, it is not represented in the Central National Herbarium (CAL) and is not at all represented in the Regional Herbarium at Shillong (ASSAM). Keeping in view the taxonomic and botanical interest of such taxon, it is necessary to recollect and conserve this poorly represented monotypic taxon and grow it under suitable conditions for preservation. A detailed description, with ecological notes and illustration based on my collection is provided.

Blechnidium Moore, Octava Nat. Print. Brit. Ferns 2: 210. 1860, Types Species: *B. melanopus* (Hook.) Moore, *l.c.* (= *Blechnum*


CM
1
3
CM
2
MM
0·5mm
4

Figs. 1-4. *Blechnidium melanopus* (Hook.) Moore.
1. Plant; 2. Scale; 3. A part of Lamina; 4. Sporangia.

melanopus Hook. Sp. Fil. 3: 64. t. 161. 1860).

Blechnidium melanopus (Hook.) Moore, Octava Nat. Print. Brit. Ferns 2: 210. 1860. Bedd. Ferns Brit. India t. 50. 1865; Handb. Ferns Brit. India 133. t. 67. 1883 *Blechnium melanopus* Hook. Sp. Fil. 3: 64. t. 161. 1860.

Terrestrial. *Rhizomes* creeping, slender, 5-8 mm diam., densely scaly, scout, with fibrous roots. *Roots* Wiry, with dark brown ramenta. *Scales* 4-6 x 1.0-1.5 mm, lanceolate to oblong-lanceolate, acuminate, membranous, brown. *Fronds* 25-45 cm long, 3.0-4.5 cm broad, articulate. *Stipes* 12-30 cm long, ± 2 mm across, wiry, terete or obscurely ridged, glabrous, shining black, reddish-black when young. *Lamina* 12-25 cm long and 3.0-4.5 cm broad, lanceolate to oblong, narrowed at base, acuminate, pinnatifid; lobes 20-22 pairs below the acuminate apex, reflexed at margin, coriaceous glabrous; basal lobes 4-5 x 6-8 mm, suborbicular, obtuse at apex; lobes 8-25 x 5-8 mm, oblong, falcate, acute or obtuse at apex; apical lobes 1-2 lobulate or entire, obtuse; veins anastomosing forming large arched areoles, ultimate veinlets free; costae distinct, whitish grey. *Rachis* 10-20 cm long, glabrous, black upto the middle of lamina from base. *Sori* 5-15 mm long, along either sides of costa, linear, continuous, indusiate. *Sporangia* 200 mm. obovoid, annular, stalked, brown (Figs. 1-4).

Ecological notes: In undergrowth in primary forest. Soil clay-loam with much humus.

Specimen examined: India, Arunachal Pradesh, Lower Subansiri District, 12 km East of Begi, ± 1800 m; 26th April, 1980, *G. D. Pal* 78265 (ARUN).

Distribution: Taiwan, and India (Meghalaya, Arunachal Pradesh).

Local name and uses: *Tari* in Apatani; *Tafeo* in Nishi. The entire plant is used in all festivals.

Note: This taxon should be incorporated in the National List of endangered species.

ACKNOWLEDGEMENT

I thank to Dr. K. Thothathri, Joint Director, Botanical Survey of India for guidance.

G. D. PAL

BOTANICAL SURVEY OF INDIA,
ARUNACHAL FIELD STATION,
ITANAGAR-791 111.

REFERENCE

BEDDOME, R. H. (1883): Handbook to the Ferns of British India, Ceylon and the Malay Peninsula, Calcutta.

APPENDIX

The Editors' Who's When

A scrutiny of the *Journal* for the names associated with the editing of the 83 volumes, from its inception in 1886 to the present day, reveals as follows:

Vols. I-II (1886-7): R. A. Sterndale & E. H. Aitken.
„ III-XI (1888-97): H. M. Phipson.
„ XII-XVI (1898-1904): H. M. Phipson & W. S. Millard.
„ XVII (1907): W. S. Millard, E. H. Comber & L. C. H. Young.
„ XVIII-XXVI (1907-1918): W. S. Millard, R. A. Spence & N. B. Kinnear.
„ XXVII-XXIX (1920-23): R. A. Spence, B. C. Ellison & S. H. Prater.
„ XXX (1924): R. A. Spence, P.M.D. Sanderson & S. H. Prater.
„ XXXI (1926): R. A. Spence & S. H. Prater.
„ XXXII (1927-8): R. A. Spence, P. M. D. Sanderson, S. H. Prater & Sálim Ali.
„ XXXIII (1928-9): R. A. Spence, S. H. Prater & Sálim Ali.
„ XXXIV-XXXV (1930-32): R. A. Spence & S. H. Prater.
„ XXXVI-XXXVII (1932-34): R. A. Spence, P. M. D. Sanderson, S. H. Prater & C. McCann.
„ XXXVIII-XL (1935-39): P. M. D. Sanderson, S. H. Prater, C. McCann, H. M. McGusty & J. F. Caius.
„ XLI-XLIII (1939-43): H. M. McGusty, J. F. Caius & S. H. Prater.
„ XLIV (1943-44): J. F. Caius, S. H. Prater & C. McCann.
„ 45-47 (3) (1944-48): S. H. Prater, C. McCann & Sálim Ali.
„ 47 (4)-48 (2) (1948-49): Sálim Ali & S. B. Setna.
„ 48 (3)-51 (1949-53): Sálim Ali, S. B. Setna & H. Santapau.
„ 52-56 (1954-59): Sálim Ali & H. Santapau.
„ 57-59 (1960-62): H. Santapau & H. Abdulali.
„ 60-61 (1963-64): H. Santapau & Z. Futehally.
„ 62-63 (1965-66): H. Santapau, D. E. Reuben, Z. Futehally & J. C. Daniel
„ 64-67 (1967-70): H. Santapau, Z. Futehally & J. C. Daniel.
„ 68-70 (1971-73): Z. Futehally, J. C. Daniel & P. V. Bole.
„ 71-83 (1974-86): J. C. Daniel, P. V. Bole & A. N. D. Nanavati.

The Editors' Who's Who

1. Humayun Abdulali

One of India's leading ornithologists and author of two regional checklists. He was the Society's Honorary Secretary from 1954 to 1962 when there were many changes in its organisation. It was the period when the Society cut its umbilical chord with Phipson & Co. and the Natural History Section of the Prince of Wales Museum. His most notable contribution was the successful negotiation with the Government of India and the Prince of Wales Museum for the building to house the Society's offices — Hornbill House.

2. Edward Hamilton Aitken

Better known as EHA, hardly requires introducing. As author of several books which have become almost classics, he enjoys a wide reputation as a naturalist. 'Behind the Bungalow', 'Tribes on my Frontier', 'A Naturalist on the Prowl' and 'Common Birds of Bombay' are amongst his most popular writings. Indeed EHA is claimed by some to be India's greatest naturalist-writer, and a perusal of his books shows that this is by no means an exaggerated view. He was an exceptionally keen observer of nature, interested in everything that lived and breathed and possessed the gift of humorous and imaginative, yet scrupulously accurate, description such as has seldom been surpassed or equalled. When EHA resigned his editorship of the *Journal* in 1887, presumably because of transfer from Bombay, his place was taken by H. M. Phipson who had in the meantime returned from leave in England.

Sir Norman Kinnear relates that in an obituary notice that appeared on his death in 1909 in a local newspaper of his provincial home town in Scotland, EHA was described as an expert on Indian birds, Bungalow Economy and the Frontier Tribes! How EHA himself would have enjoyed this description can be imagined by any one familiar with the spirit of his writings.

3. Sálim Ali

Has had a long and active association with the Society. His chief interest is birds, particularly the field aspects of their study, and he is the author of several books on Indian birds. He served as one of the editors in 1927-28 (Vols. 32 and 33), and resumed his connection with the *Journal* in 1944 (Vol. 45), collaborating with S. H. Prater and C. McCann. Upon their leaving India, Sálim Ali took over as General Editor assisted by Dr. S. B. Setna for a year, when Fr. H. Santapau joined the board. Presently the Society's President.

4. P. V. Bole

Retired as Professor of Botany at St. Xavier's College, Bombay and is actively associated with the Blatter Herbarium and the Society for almost 30 years. He has contributed papers on floristics of W. India, plant ecology and survey of economic plants as well as on ethnobotany. He is interested in conservation of natural habitat and propagation of indigenous plants.

5. Fr. Jean Ferdinand Caius, s.j.

A distinguished biochemist, was Professor of Chemistry in St. Xaviers College, Bombay, from 1922, and founder and first director of the Pharmacological Laboratory at the Haffkine Institute (Government of Bombay) from 1924-1932. He became Honorary Secretary of the Society in 1941 and served as Chairman of the Sub-Committee of Trustees of the Natural History Section of the Prince of Wales Museum, and as one of the editors of the *Journal* till his death in 1944. He was an indefatigable worker and among his more outstanding scientific achievements were the intensive investigations he carried out at the Haffkine Institute on the therapeutic value of various remedies employed against diseases caused by hookworm and roundworm, so prevalent in India. His work has been recognised as the most exhaustive and complete treatise on the subject and is widely quoted in most text books on pharmacology. Another contribution by Fr. Caius was his extensive studies of the poison apparatus of snakes and of the remedies employed against snake poisons, particularly those alleged to be efficacious in the Ayurvedic and Unani systems of medicine. His experiments proved that all of such cures, even those most widely reputed, were completely ineffective against cobra and viper venom.

He contributed a valuable series of articles to the *Journal* on the Medicinal and Poisonous Plants of India, and completed the revision started by the late Fr. Blatter, of Kirtikar and Basu's Medicinal Plants of India'.

Fr. Caius died in Bombay in July 1944. A full obituary notice appears in Vol. 45, pp. 79/80.

6. Edward Comber

A partner in the Liverpool firm of East India Merchants, Lyon, Lord & Co., was one of the most active members of the Society in its early years. He was a great yachtsman, and keenly interested in birds and insects though his many notes and articles between Vols. 10 and 20 of the *Journal* cover practically every branch of animal life and reveal the wide range of his natural history interests. Among his contributions is a series 'Hints to Beginners on collecting and preserving Natural History Specimens'—Mammals (Vol 13; 100), Birds (Vol. 13; 270), Reptiles & Amphibians (Vol. 13; 641) and Fishes (Vol. 17; 396), which by the help they afforded upcountry members, were largely instrumental in building up the Society's zoological collections from different parts of the country. Comber was largely responsible for the proper care and cataloguing of the various collections, lists of which he published in the *Journal* from time to time. Also for preparing the first General Index for Vols. I to XII.

7. J. C. Daniel

Studied at the Madras Christian College and the Madras University Zoology Research Laboratory. He joined the Society as a Research Assistant in 1950. Joined the Natural History Museum at Darjeeling as Curator in 1955 and returned to the Society as its Curator in 1960. His interest in natural history is eclectic, with a leaning towards reptiles and wildlife conservation.

8. Bernard C. Ellison

Was selected on behalf of the Society by R. C. Wroughton (who was working in the British Museum on the collections of the Mammal Survey) on Kinnear's departure from India, and sent out as curator to Bombay in 1920. The choice would, on the whole, seem to be an unfortunate one since

Ellison—overtly, at any rate—possessed few of the qualifications that might be expected in the curator of a natural history museum or in the editor of a scientific journal. Ill health terminated his contract with the Society early, and he returned to England in 1923.

9. N. B. (Sir Norman B.) Kinnear

Came out to India in 1907 as the first wholetime curator of the Society. He had had his training in the Royal Scottish Museum at Edinburgh under the wellknown ornithologist Dr. William Eagle Clarke, and his advent marked the immediate shift of the Society's activities to a more scientific plane through a proper rearrangement, labelling and cataloguing of its various collections. His staff work in connection with the Society's Mammal Survey was invaluable, and the success of the undertaking is due in no small measure to the care he bestowed on its planning and direction. His main influence on the *Journal* was also in the direction of a greater scientific bias. He encouraged and guided many young people to develop their particular interests in natural history, and several of the names that have since gained prominence in its pages can be claimed to have derived their inspiration largely from Kinnear. He published numerous notes and short articles in the *Journal* on various branches of Indian history, and through country-wide correspondence with outstation members elicited a wide range of useful and interesting matter for the Miscellaneous Notes section.

Kinnear's special interest lay in Mammals and Birds, and field study in these two branches received a great fillip whilst he was in the country. Since his return to London he has maintained a lively interest in the affairs and progress of the Society and rendered valuable assistance to it in various ways. He has also contributed important papers on birds of the Palaearctic and Oriental Regions to the *Journal* including the report on the Vernay Scientific Survey of the Eastern Ghats—writing in collaboration with the late Hugh Whistler—which, by showing up the many gaps in our knowledge of Indian ornithology led the way to the useful regional bird surveys that have since been sponsored by the Society.

Kinnear left India in 1919 to take up an appointment in the Bird Room of the British Museum (Natural History), London. He rose to be Director in 1948, an eminence from which he retired in 1950.

10. Zafar Futehally

Took over from Humayun Abdulali as Honorary Secretary. An avid birdwatcher, Zafar has the ability to communicate his enthusiasm to others. It was during his stewardship that the Society stopped being introspective and widened the scope of its activities. Zafar is the founder of the Birdwatchers' Field Club of India and editor since its inception in 1960 of the Newsletter for Birdwatchers' now in its 26th volume.

11. Charles McCann

Joined the Society as a collector in the Mammal Survey in December 1921 and was appointed Assistant Curator in 1922 and Joint Curator in January 1946. Later in the year he resigned his post and left India.

The minute of the Society's Executive Committee dated 14th November 1946 recording its appreciation of his services and regret at his resignation gives a good sketch of McCann's career. It reads in part as follows:—

'The merit of his scientific work is evidenced in his many biological contributions to the journal of the Society. He is one of the outstanding botanists in India and his monograph on Grasses which he wrote jointly with the late Father Blatter, and which was published under the aegis of the Imperial Council of Agricultural Research, will remain for many years the standard work on the subject. Equally outstanding in merit are his various revisions of the genera and species of Indian plants which the Society was privileged to publish. Mr. McCann also contributed various authoritative papers on Indian Mammals, Reptiles and Amphibia. They are based on careful field work and observations. The study of Nature was his absorbing passion and his main recreation.

In the Museum his services were invaluable, and the galleries of the Natural History Section of the Prince of Wales Museum and the fine range of groups and well-mounted exhibits owe much to his skill and ability. His resignation is a great loss to the Society.'

McCann was indeed a phenomenal field naturalist. His powers of observation were uncanny in their keeness and incisiveness Nothing escaped his attention as he tramped through the jungles of his beloved Western Ghats. The degree of his familiarity with all living things was such that whether it be plant or rat, bird or snake, lizard or frog, butterfly or snail, he could identify it pat and without hesitation correctly down at least to the genus in nine cases out of tea, and often give you the species as well!

12. McGusty

12. H. M. McGusty

Was a senior assistant in the firm of Phipson & Co., which has had a traditional unbroken connection with the B. N. H. Society from the time it was founded. He served the Society variously as Honorary Secretary and Honorary Treasurer for several years between 1934 and 1941 when he finally left India. His connection with the *Journal* was, however, purely ex-officio and titular, and he had no active hand in editing it.

13. Walter Samuel Millard

Who took over from Phipson in 1906, had already been associated with the editorship since Vol. 14 (1903). Millard proved an admirable successor to Phipson, and the period of his stewardship may be called the period of consolidation for the Society, when it expanded widely both as regards membership and usefulness. His most notable contribution to its progress and scientific reputation was the organising and carrying out of the Mammal Survey of India, Burma and Ceylon, a full account of which is contained in Part III (pp. 86-89) of the Society's Jubilee volume published in 1934.

Millard was an expert gardener, and his garden on Malabar Hill is still remembered with pleasure and nostalgic envy by some of the older residents of Bombay. His short notes in the *Journal* cover many branches of natural history, and jointly with Rev. Fr. Blatter he was author of 'Some Beautiful Indian Trees', an attractive well-illustrated book published by the Society in 1937.

Millard left India on retirement in 1920, and died in 1952. An obituary notice appears on p. 910 of Vol. 50.

14. A. N. D. Nanavati

Was the first medical man to take over the administration of the Society. A virologist, he was Asstt. Director of the Haffkine Institute at Bombay till his retirement in 1974. Dr. Nanavati's dispassionate assessment of issues has strengthened the Society's handling of problems that arise.

15. Herbert Musgrave Phipson

Was a truly remarkable man. During the early years of the Society, Phipson as Honorary Secretary and Editor was its virtual 'Ma-bap'. It is largely to his keenness and contagious zeal as a naturalist, his devotion to the cause, his untiring enthusiasm and energy, and above all to his wonderful personality that the Society and its journal owe their growth and prosperity. This was the truly formative period, and the firm foundation upon which Phipson built has enabled the Society to weather the storms and stresses of subsequent years.

Phipson's particular interest lay in Snakes and he contributed a great deal to their study; but except for a few short notes he unfortunately published little of his own observations in the *Journal*. He left India in 1906 and died in London in 1936. A good biographical sketch of H. M. Phipson appears on pages 152-154 of Volume 39 (December 1936).

16. Stanley Henry Prater

Had entered the Society's service in 1907, working first under the guidance of E. Comber and subsequently as assistant to N. B. Kinnear. He was a voracious and discriminating reader, particularly of natural history books in his early years, had the power of assimilating what he read, and was blessed with a remarkably retentive memory. He was a clear and lucid descriptive writer with a pleasant easy style; a good artist and modeller, and dextrous with his hands in other ways. He possessed an almost uncanny aptitude not only for picking up techniques but for passing on what he learnt to his assistants and then getting the best out of them. These qualities, fortified by the practical experience he had acquired and a course of academic grounding in systematic zoology with the late Fr. E. Blatter to provide the necessary scientific background, fitted Prater admirably for taking charge of the Society's museum and journal. Prater's *forte* was his capacity to pick out the essentials of anything he read—of separating the grain from the chaff—and of clothing the substance in clear jargon-free language. He was a master in the art of compilation. The skill and discernment with which he would browse among heavy scientific literature and the facile way in which he connect up and expound disjointed facts culled from a dozen sources and produce harmony from them, excited the admiration and envy of less gifted souls. It is but natural that a person possessing all these advantages should, up to a point, dominate his colleagues, and indeed from the time his name first appears on the cover of the *Journal* —Vol. xxvii (1920)—and up to the time of his retirement in 1948. Prater virtually ruled the editorial roost. He had the contents of all the previous volumes at his fingers' tips and could recall everything published on any topic before, by whom and when, and could turn to it without effort or fumbling. His familiarity with the Society's reference library was also such that he knew exactly where to turn for just the information needed. And how most effectively to make use of that information is of course what he excelled in. As a natural historian he was an all-rounder, having had, during his long connection with the Society, the opportunity of working fairly thoroughly through all its collections and acquiring a wonderful general knowledge of the various branches. He could name straightway almost at a glance, most specimens brought in by members of the less uncommon mammals, birds, reptiles, amphibians, fishes, butterflies and many other groups of insects, and could usually tell of their distribution and habits as well. His numerous notes and articles in the *Journal* cover a very wide range of natural history topics. Though not a specialist in any particular branch, he was perhaps more at home with birds and snakes than with other groups. Yet such was his general grasp and versatility that whatever he chose to write on bore the imprint of authority. Indeed he wrote nothing of doubtful authenticity since all his basic facts were garnered from authoritative sources. His masterly treatment of The Whale Shark in Indian Coastal Waters (Vol. 42; 255) and Fish Supply of the West Coast of India (Vol. 34; 973 & Vol. 35; 77) and The Game Fishes of Bombay, etc. (Vol. 36; 29) are examples. On perusing them it seems inconceivable that they should be written by any but a specialist—so sound and facile are they.

It was largely during the run of Prater's editorship that the Society's journal attained the esteemed position it now enjoys among the scientific periodicals of the world; of course we were fortunate also in our contributors who included an increasing number of workers of distinction in the international field.

Prater retired in 1947 after some 40 years of devoted service to the Society.

17. D. E. Reuben

A member of the ICS who retired as Chief Justice of Bihar before settling in Bombay. Mr. Reuben's meticulous editing was of considerable help when Sálim Ali retired as Executive Editor. Mr. Reuben though his name was on the editorial board only very briefly was a *de facto* editor of the *Journal* over several volumes.

18. P. M. D. Sanderson

Also of the firm of Phipsons, whose name flicks sporadically on the editorial board first in 1924 (Vol. XXX) and again in 1928 as an editor for Vol. XXXII (4), acted as Honorary Secretary during Sir Reginald Spence's periodic absences on leave in England. He was also one of the old brigade with Millard and Spence who had had their introduction to Indian natural history under Phipson's tutelage. On Spence's retirement from India in 1934, Sanderson took over from him as Managing Director of Phipson & Co. and, in keeping with the long established tradition, more or less automatically stepped in as Honorary Secretary of the Society as well.

Though a keen naturalist and sportsman, and an enthusiastic protagonist of the Society, Sanderson's activities in regard to the *Journal* were more of a general supervisory character, and strangely enough the *Journal* carries no article contributed by him.

19. Rev. Fr. H. Santapau, s. j.

Studied at the Imperial College of Science and Technology, London, and in Kew Gardens and specialized in Plant Taxonomy. He was particularly interested in the botany of Western India and has done intensive explorative work in Khandala, Purandhar, Mahableshwar and in Saurashtra. He was director of the Biology Department of St. Xavier's College, Bombay.

20. Dr. S. B. Setna

Studied under Dr. J. Gray, Professor of the Zoological Laboratory, Cambridge University, where he obtained his Ph.D. degree. He was the Director of Fisheries, Bombay State, since the inception of the department in 1945. In this capacity he was responsible for the development of freshwater and marine fisheries in the State and also for the maintenance of the Taraporevala Aquarium. He was elected a Fellow of the National Institute of Sciences of India in 1947 and was awarded the first Chandra Kala Hora Memorial Gold Medal in 1950 for conspicuously important contributions to the development of the fishing industry.

Dr. Setna was one of the editors of the *Journal* since 1947 and was chiefly responsible for editing the articles relating to fish and fisheries.

21. R. A. (afterwards Sir Reginald) Spence

Who succeeded Millard, had likewise started his career in India as a young assistant in the wine business of Phipson & Co. He had early caught the contagion of enthusiasm for natural history from his chief, and was nurtured in this interest through Phipson's guiding care. During Spence's long association as its Honorary Secretary, the Society may be said to have attained its flowering. His genial personality won him many friends, and the esteem he commanded both with the public and with Government reflected beneficiently on the affairs of the Society. He brought to fruition the negotiations started by his predecessors regarding the transfer of financial responsibility for the housing and proper care of the Society's zoological collections from the Society to the Government of Bombay, and had the satisfaction of feeling the imminent fulfilment of his labours before leaving India in the detailed plans for the completion and utilization of the beautiful new natural history wing of the Prince of Wales Museum, Bombay, which has since come into being.

As editor of the *Journal* Spence was fortunate in having the able collaboration first of N. B. Kinnear, a trained and experienced zoologist lately out from England as the Society's first stipendiary curator, and then, after 1919, of S. H. Prater who succeeded him in office.

Though increasing demands on his time from business and social work caused Spence latterly to leave much of the actual editing to his colleagues, he nevertheless continued to take a lively interest in the welfare of the *Journal* and to guide its general policy.

His outstanding contributions to the *Journal*, both written jointly with Prater, were the articles on 'The Fish Supply of the Western Coast of India' (Part I, Vol. xxxiv; 973, Part II, Vol. xxxv; 77) and 'Game Fishes of Bombay, the Deccan and the Neighbouring districts of Bombay Presidency' (Vol. xxxvi; 29).

Sir Reginald left India on retirement in 1934.

22. Robert Sterndale

Came to Bombay soon after the Bombay Natural History Society was formed in 1883, and at once joined it and worked for it with his characteristic enthusiasm. The idea of starting a journal originated with him and 'proved practicable only because of the way in which his ready pen and pencil solved all difficulties.' Being an exceedingly keen and versatile field naturalist, he himself contributed many interesting articles and was largely responsible for getting the *Journal* under way. Sterndale is perhaps best known as the author of 'Natural History of Indian Mammalia' which, published in 1884, is still one of the standard reference books. He ended his official career as Governor of the island of St. Helena, and died in 1902.

23. L. C. H. Young

Who, with E. Comber, was an editorial collaborator of Millard's for Vol. 17, came out to Bombay about 1903 on the staff of the insurance department of Forbes, Forbes, Campbell & Co. He was a Marlborough man, and a keen and knowledgeable lepidopterist, being a disciple of the distinguished entomologist, E. Meyrick, F.R.S., whom he got to write the monumental papers on Indian Microlepidoptera, published between Vols. 18 and 23 of the *Journal*. He reorganised, re-set and re-catalogued the Society's butterfly collection and published several useful notes and papers, chiefly on butterflies, between Volumes 15 and 17 of the *Journal*. The serial on 'The Common Butterflies of the Plains of India' was originally started by Young in Vol. 16. He had to give it up after the first 3 parts owing to ill health. It was taken up by another distinguished lepidopterist-member T. R. Bell, I.F.S., in Vol. 19 who conducted it for 16 years, concluding it finally in Vol. 32.

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